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PRELIMINARY NOTES ON THE ARCHÆOLOGY OF THE YAKIMA VALLEY, WASHINGTON.

By Harlan I. Smith.

Archæological explorations were made in the Yakima Valley, Washington, for the American Museum of Natural History in the first part of the field season of 1903, resulting in the discovery of specimens and human skeletons, as well as the securing of several dozen photographs and a mass of field notes. Other data have been secured, both before the expedition and since, from collections and museums. The following preliminary account is made up from these results which may not be published in full for some time.

Central Washington is arid. In most respects the climate resembles that of the southern interior of British Columbia to the north. The summers are perhaps warmer and the winters colder. There is less vegetation and no trees are seen except in river bottoms or where irrigation has been successfully prosecuted. The prehistoric people had no great staples and had to rely upon perhaps even a greater variety of natural products than did the people to the north.

A glance at the linguistic map of Washington shows the great number of tribes inhabiting the general region. This suggests the possibility of the existence of more than one culture area within the same territory, although, of course, we may find several tribes, especially if they be subjected to the same environment, all within one culture area.

Definite age can not be assigned to the archæological finds, since here, as to the north, the remains are found at no great depth or in soil the surface of which is frequently shifted. Some of the graves are known to be of modern Indians, but many of them antedate the advent of the white race in this region or at least contain no objects of European manufacture such as glass beads or iron knives. On the other hand, there was found no positive evidence of the great antiquity of any of the skeletons, artifacts or structures found in the area.

The implements used in securing food include many chipped projectile points of bright-colored agates, chalcedonies and similar stone. Several small quarries of this material with adjacent workshops were found. While the bulk of the stone used was quite different from the black basalt employed almost exclusively to the north, yet a few points chipped from that material were also found. Points rubbed out of stone or bone were rare. Digging-stick handles were seen, but no sap-scrapers were found.

Some small heaps of fresh-water clam shells were examined, but these being only about five feet in diameter and as many inches in depth are hardly to be compared to the immense shell heaps of the coast. Net-sinkers were made by notching and grooving pebbles. Such sinkers were very rare to the north and much more numerous here than on the coast, except near the mouth of the Columbia River, where grooved sinkers, usually slightly different from these, are found.

For preparing food, pestles were used. These differ from those found either to the north or on the coast. Some had tops in the form of animal heads. Fish knives made of slate were not found and pottery was not made in the region.

Sites of ancient semi-underground houses, like those found in the Thompson River region, were photographed, but here stones were more frequently seen on top of the embankment. No saucer-shaped depressions were seen, but circles of stones were found, which may mark lodge sites; the modern Indian has a lodge identical in shape with that found to the north. Pairs of arrow-shaft smoothers were seen.

An idea of the ancient form of dress was obtained from a costumed human figure carved in antler. It had a feather head-dress like that of the present Indians of the region from here to as far east as the Dakotas. The hair is dressed and ornamented with dentalium shells. The body is represented as painted, with a fringed apron around the loins. The costume indicated is unlike that of the coast, but resembles that of the plains.

Besides a tubular form of pipe, one type consisting simply of a bowl was found. This is not often seen among the archæological remains in other parts of the Northwest, although pipes used by the Thompson River Indians seem to resemble it. The fact suggests that the culture of this region is somewhat more closely related to that farther east than are the cultures of the areas to the north and west.

Art work was found here as in the other areas. The object made of antler, engraved on one surface to represent a human figure in costume, which was found in the grave of a little child, is of good technique and artistic execution. The circle and dot design was common. Paintings made with red and white on basaltic cliffs, many of which represent human heads with head-dresses and some the whole figure, were also seen. These were made up of lines and were pictographic in character. Sometimes such pictures were made by pecking into the surface of the columns, instead of by painting. A design, similar to the part of these pictures interpreted as representing the head-dress, was also found pecked into the surface of a grooved net-sinker. Some of the pestles had tops in the form of animal heads, but in general the art of the region tended to line work of geometric and pictographic patterns. The general style of art shows little resemblance to that of the coast but a strong relationship to that of the plains.

There were three methods of disposing of the dead.

LODGE SITE MARKED BY CIRCLE OF STONES.

ASH DOMES LEFT BY WIND. BURIALS ARE MADE IN THESE.

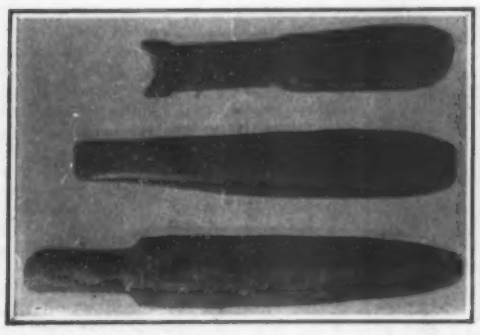
ROCK SLIDE GRAVE OPENED.

THE ARCHÆOLOGY OF THE YAKIMA VALLEY, WASHINGTON.

In this arid region are stretches of country locally known as "scab-land," on which are occasionally groups of low dome-shaped knolls from about fifty to one hundred feet in diameter by three to six feet in height. These knolls consist of fine volcanic ash, and apparently have been left by the wind. This ashy material has been swept from the intervening surface, leaving the "scab-land" paved with fragments of basalt imbedded in a hard soil. The prehistoric Indians of this region have used many of these knolls, each as a site for a single grave. These graves, which are located in the tops of the knolls, are usually marked by large river pebbles, or in some cases by fragments of basalt, that appear as a circular pavement projecting slightly above the surface of the soil. In one only did we find a box or cyst formed of thin slabs of basaltic rock placed on edge to form a box covered with two large flat slabs. Above this, as was usually the case above the skeletons in this sort of grave, the space was filled with irregular rocks or pebbles. The skeletons were found flexed on the side. In the grave artifacts, such as dentalium shells, were deposited at the time of burial. Simple graves in the level ground were not found. The rock slides, as in the region to the north, had frequently been used as burial places. In these the skeletons were always in a flexed position. Objects were found to have been placed in some of these graves. Rings of stones were also seen and on excavation within them the cremated remains of several people were found. In such places dentalium shells, flat shell beads and shell ornaments were usually seen.

The prehistoric culture of the region was apparently similar to that of the present natives.

Numerous evidences were found of the close communication of the people of this culture with tribes of the southern interior of British Columbia. The



WAR CLUBS MADE OF STONE.

preponderance of chipped over ground points, digging-stick handles, sites of semi-underground houses, pestles with tops in the form of animal heads, pairs of arrow-shaft smoothers, as well as tubular pipes, an incised decoration consisting of a circle with a dot in it and engraved dentalium shells each of a particular kind, besides rock-slide sepulchers and the custom of burying artifacts with the dead, were found to be common to both regions. Certain pestles and clubs made of stone differed from those found in British Columbia, while the chipped implements were made of greater variety of stone and of more beautifully colored material. Notched and grooved sinkers were much more common, and sap-scrapers were not found.

Considerable material of the same art as that found in the Lytton region was seen. It is clear that the people living in the Yakima Valley had extensive dealings not only with the tribes northward as far as the Thompson Valley, but also southward as far as the Dalles of the Columbia. In this connection it is interesting to note that the present Indians of the region travel even more extensively than would be necessary to distribute their artifacts this far.

Much less evidence of contact between the prehistoric people of the coast and that of the Yakima Valley was discovered. Many of the pestles and clubs made of stone were different from those found on the coast, where, it will also be remembered, artifacts were not found with the dead. A pipe, however, and sea shells of several species were seen. The pipe is clearly of the art of the northwest coast. It was found far up the Toppenish River, one of the western tributaries of the Yakima.

COMB MADE OF ANTLER.

In general, the culture of the prehistoric people resembled that of the present natives and was affiliated with the cultures further east, but different from both the prehistoric and present culture of the coast to the west and even of the southern interior of British Columbia to the north.

From the whole series of archæological explorations in British Columbia and Washington, begun in 1897 for the Jesup North Pacific expedition and continued in 1903 for the American Museum of Natural History, we have learned that the material culture of the prehistoric people and the present natives was similar in each area examined; that the culture of the coast is of one sort, that of the interior of southern British Columbia of another, from which that of central Washington differs somewhat; and that there are several small culture areas lying adjacent to these. We find that each culture apparently developed independently, but that at various times, especially in the past, each has been influenced by one or more of the others.

In general, the culture of the North Pacific coast does not extend far inland. Northward its limits are unknown, but southward it coalesces with that from the Columbia River in the region between Seattle and Shoalwater Bay. In the interior we have a plateau culture which at the north differs somewhat from that at the south.

Experience in this work emphasizes the advisability of conducting archæological investigations in co-operation with students of living tribes. A study of the modern Indian living in the country in question usually throws light on archæological finds made there, while an understanding of the antiquities of a region often helps in the study of the present natives. Besides, in this way the continuity of the historical problem is met by a continuity of method.

In selecting successive fields of operation, it seems best always to continue explorations in an area so far distant from one already examined that new conditions will be encountered. This will make it probable that new facts will be discovered, if not a new culture area. At the same time the new field of operations should be near enough that no culture may intervene. Thus the boundaries of culture areas may be determined and new areas discovered. This method of continuation from past fields of exploration allows any experience there gained to be of service in each new and adjacent field, while the discoveries in each new region may always lead to a better understanding of the areas explored and that perhaps in time for incorporation in the results to be published.

It remains to determine the northern, eastern, and southern limits of the general plateau culture, how far it may be subdivided into local culture areas, the interrelation of each of these, and of each to outside cultures.

But few specimens have been found in the whole area lying between the central Arctic region and the Columbia River, and from there southward along the coast to the Santa Barbara Islands, thence to the Pueblo region and eastward as far as the mounds of the Mississippi Valley. Literature on the archæology of the area is scanty. That whole region, north to the Arctic, across all the plains toward the east, and the plateaus south throughout Nevada, remains to be explored.

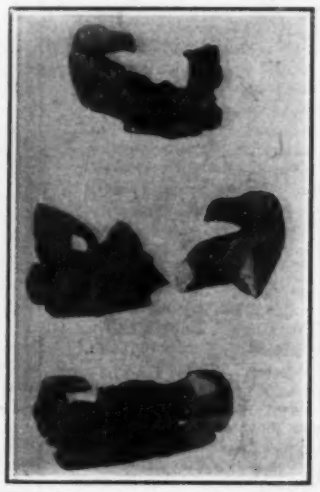
PICTOGRAPHS IN WHITE PAINT ON BASALT CLIFFS.

THE ARCHÆOLOGY OF THE YAKIMA VALLEY, WASHINGTON.

THE "COCO DE MER."

By the late NICOLAS PIKE.

THE Coco de Mer is undoubtedly the most remarkable plant existing in this colony and its dependencies, and the only spot in the world in which it is indigenous. The fruit was known long before the plant which produces it, or the locality in which it is found;



CARVED PIPE. CRAFTSMANSHIP SHOWS CONTACT WITH THE COAST.

and various fables were invented as to its origin, and marvelous virtues were attributed to its qualities. The few known specimens of it which existed were valued at an enormous price, till in 1742 the discovery of the Seychelles Archipelago made known the habitat and nature of this singular production.

The name of the "Coco de Mer," or "sea cocoanut," was given in consequence of the first specimens of it which were known having been found floating on the sea, into which they had been carried by the streams, and some of these having been met with in the neighborhood of the Maldive Islands, their name was added to that of the Coco de Mer.

When the Seychelles Archipelago was discovered, three of the islands composing it, Praslin, Curieuse, and L'Ile Ronde, were covered with magnificent forests of this unique palm, and their soil strewed with its huge and singularly-shaped nuts. The value of their shells as domestic utensils for various purposes was at once perceived, and from that time to the present they have supplied to the inhabitants the place of buckets, bowls, jars, dishes, measures for grain and liquids, drinking vessels, paint pots, etc., and they were extensively used among the laboring population of Mauritius, until the diminution of the plant, and the great demand for the fruit, which has arisen within the last few years in India and Persia, and which has greatly enhanced their value.

The palm which produces this singular nut is the only member of its species. Its systematic name is *Lodoicea Sechellarum*. It may be termed an equatorial plant, the islands in which it is found lying between 4 deg. 15 min. and 4 deg. 21 min. south latitude and 55 deg. 39 min. and 55 deg. 49 min. east longitude. Its stem attains a height of eighty or ninety feet, and is quite straight, cylindrical, and smooth, but slightly marked throughout its length by the scars left by its fallen leaves.

The scars are naturally more or less distant from each other, according to the rapidity of the growth of the plant. On the barren hillside they are scarcely two inches apart, while in the moist and fertile gorges they are as much as three. The diameter of the stem varies, from the same causes, from twelve to fifteen inches. A stalk as long and slender, crowned by leaves of vast size and strength, is necessarily much influenced by the wind, and in strong breezes they bend considerably, while their elasticity causes them to wave in the most graceful manner.

The clashing of the leaves in a stiff gale produces a louder noise than I have heard from any other trees,

and quite of a different nature, and the occasional fall of the ponderous fruit renders a passage among the sea cocoanuts a somewhat dangerous affair except in calm weather. I have heard of an instance of a woman being struck by one, while washing at a brook; a companion who was washing beside her was only made aware of the circumstance by the fall of the nut. The victim died without a cry or groan. The stem of this, like other palms, consists of a mass of hard fibers, inclosing a medullary substance; but the fibrous portion of the stalk of the Coco de Mer is harder than that of any other palm I know, and can only be cut by a sharp and well-tempered tool. The form of the stem likewise resembles that of most members of the family, its largest portion being that which rests on the surface of the ground. The root is in some cases bell shaped, in others nearly hemispherical, and a vast number of rootlets radiate from it in all directions. These extend to a great distance around it, and form admirable stays to resist the strain to which the play of so long a lever subjects them; and so well do they perform their offices that I have never known an instance of a Coco de Mer having been thrown down. I am aware that the same disposition of the roots exists in most other palms; but this by no means lessens the admiration due to such a perfect adaptation of means to an end.

The rootlets are cylindrical, from half to three-quarters of an inch in diameter, and consist of a very strong bark inclosing a soft parenchyma. A beautiful exhibition of the roots is afforded when the palms have been burnt; the charred roots, almost as sonorous as metal, and as brittle as glass, show the great proportion of silica which they contain; and the numerous little tubes which radiate around have been left empty by the decay of the medullary substance which filled them. I have seen some instances in which the radius of these rootlets exceeds twelve feet.

The leaves of the Lodoicea are winged and palmated, and bear a great resemblance to those of the fan palm. They are largest at the time when the stem is just appearing above the ground; and in favorable situations they may be found as much as fifteen feet long, exclusive of the petiole, which is of an equal length by twelve feet wide. As the trunk increases in height, the length of the petiole and the size of the leaf diminish. Did they not do so, the strength of the stem and its supports, great as it is, could not resist the effects of the wind with so great a leverage as the lofty stem would give. The leaves are destitute of prickles; the petiole is stout and grooved from its base to the leaflets, the folds of which converge to this canal, thereby pouring all the moisture which falls on them upon the stem. The edges of the petiole are sharp, and the base of the leaf spreads so much as to embrace about two-thirds of the circumference of the stem; and some fibrous filaments which spring from the lower part of the petiole assist in maintaining it in its position. The middle of the petiole presents a longitudinal fissure, which appears like an accidental cleft; of this we shall presently see the use. The petiole is so strong and so firmly attached to the stem that a man may safely sit on its extremities, and even swing upon it. I only knew one man who would venture on this dangerous feat; he was a native of the Maldive Islands, settled at Seychelles. Among all the perilous gymnastics I ever beheld, none made me shudder more than to see him seated on the leaf stalk of a Coco de Mer at nearly a hundred feet from rocky ground, rising and falling to the utmost extent the flexibility of the stalk allowed; he never met with any accident. The leaflets are of a glossy and dark green on the upper side, and whitish green slightly pubescent on the under; they form a sharp fold, and are adherent in the greatest part of their length, the free ends growing longer as they recede from the center of the leaf. The number of leaflets varies considerably; some fronds have upward of ninety. Each fold is strengthened by a strong rib or tendon. The texture of the leaf is very strong, and of a complicated formation; it consists of three layers of fibers enveloped in parenchyma. The two outer layers are longitudinal, and the central transverse, and the epidermis itself very strong. When the parenchyma and epidermis have decayed, the exposed fibers present much the appearance of coarse Scotch gauze.

The leaf previous to its unfolding is covered with a thick fawn-colored down of a cottony feel. When the trees were numerous this down was collected in sufficient abundance to form the stuffing of mattresses and pillows for the Praslinois. The most attentive observation leads to the belief that one leaf is produced every year, and from the scars left by their fall, the age of the tree may be computed. Reckoned by this standard, some of the trees must be nearly four hundred years old. The male and female flowers are produced on separate trees. The spadix which supports them springs from the same circle of insertion as the leaf which accompanies it, but instead of rising from the axil of the leaf, it passes through the fissure in the petiole. The spathe, in both, is composed of three fibrous bracts, fitting one into the other, and opening by a longitudinal fissure on the outer side. The first bract, and generally the second, are concave on that side which is against the tree; the top of the first bract forms a sharpish edge, that of the second is pointed and remains fixed in the cleft of the petiole above it, thus supporting the weight of the spathe, while the top of the third bract, which is also pointed, is free. In the male flowers, the spathe is terminated by a catkin of two or three inches in diameter, and sometimes nearly four feet long, cylindrical and rounded at the end. It is covered with brown scales, closely imbricated, but so sloped at the ends as to allow the flowers to issue; these openings form symmetrical spiral lines round the catkin. A transverse fracture of the latter exhibits a series of reticulated tubercles radiating from the axis to the circumference. These tubercles, which are nearly the shape of a nautilus shell, consist of an assemblage of about twenty sessile blossoms, in various degrees of maturity, and form a reserve in the interior of the catkin. They appear one or two at a time at the floral opening, to blow and fall in their turn.

This most curious arrangement prolongs the blossoming of a catkin to the unequaled period of six or eight years. The calyx of these flowers is prismatic and entire, and slightly cleft into three unequal lobes. The corolla is composed of three linear petals, concave at their extremity, and alternating with the divisions of the calyx. The stamens are from twenty to thirty in number, and the anthers slightly sagittiform. The pollen is yellow, and when seen through the microscope appears much like grains of barley, not only in shape, but being also furrowed longitudinally—a form common, I believe, to the pollen of palms in general. A gummy exudation of a rather strong and peculiar smell covers the surface of the catkin. In the female flowers the spadix is simple, as in the males; but instead of growing in a straight line, it forms a zigzag, from the angles of which the flowers spring.

These flowers are about three inches in diameter. The calyx is sessile and is formed of two circles of bracts, three in each circle, firmly imbricated, and almost inclosing the ovary, previous to its fecundation. The calyx is attached to the spadix by two oval bracts, but these remain attached to the spadix, while the calyx falls with the fruit. The flower has neither corolla nor style; three sharp persistent sessile stigmas rest on the top of a fibrous drupe, generally a little compressed vertically; two sometimes, but rarely three sided, in the former case containing a two-lobed nut. It also sometimes happens that two double-lobed nuts

THE COCO DE MER.

are contained in the same drupe, but it is rare to find one with three lobes. This drupe attains a length of upward of fifteen inches and a circumference of more than three feet, weighing from forty to fifty pounds. About three years after fecundation the fruit has attained nearly its full size, and is then called "Coco tendre."

It may in this state be easily cut through with a knife, and exhibits in an interesting manner the different substances of which it is composed. On the outside is the drupe, green on the outside and whitish within, of a harsh taste and astringent quality, like that of the ordinary cocoanut. This is lined with a layer of a white feculent substance, almost tasteless. This covers a yellow matter very bitter, and said to be poisonous, which envelops the perisperm, a jelly-like mass presenting much the appearance of thick cold starch, very slightly tinged with blue; this has a sweetish taste and is considered cooling, and is much esteemed by the Seychellois. In the center of this, at the period of the junction of the two lobes, lies the embryo; in the mature state, which is not till seven or eight years after the fecundation, the drupe has become fibrous, and from a rich dark green has turned to a reddish yellow, and falls from the stem. Germination takes place sometimes before, sometimes after the fall of the fruit, the shell of which is hard and black, and marked all over by traces of the fibers which were inserted in it, and a bunch of these fibers, much resembling coarse black hair, remains in the orifice from which the germ sprouts. The yellow bitter substance has become a leathery skin inclosing the perisperm, and the soft jelly-like mass has been condensed into a tasteless kernel, as hard as beechwood, of pure white color, leaving a large cavity in each hole of the nut; and at the point of junction of the two lies the embryo, of tubular form. The germ in passing through the orifice mentioned becomes fibrous and assumes a club shape, and curves toward the ground, which it penetrates.

The radicle descends vertically, and from it sprout the rootlets. At a depth of two or two and a half feet sprouts a fibrous leaf at an angle of about forty-five degrees. This leaf seems to fill the place of a cotyledon which follows it and springs from its side. Each succeeding leaf becomes larger and approaches more nearly to a vertical direction, till the crown is formed, when they succeed each other in the usual way.

The trunk does not show itself till twenty or twenty-five years after the germination of the nut, and for ten or fifteen years from this period the plant is in its greatest beauty, and begins to blossom. As many as eight or ten spadices may be seen on a tree at the same time, the male flowers, as has been said, retaining their bloom, and the female flowers seem to have the power of waiting an infinite period for fecundation. Six or seven full-sized drupes may be sometimes seen on one spadix; but although as many as eight female flowers may be seen on one stem, it is rare to see more than three or four arrive at maturity. Imperfect fecundation often takes place, and a partial development of the drupe goes on.

In this case it becomes deformed, assumes a curved shape, and falls a useless abortion. The Coco de Mer grows in every kind of soil, but attains its greatest size and beauty in the deep moist gorges of the mountains, where a rich bed of humus favors the growth of that as well as other palms, some of which greatly surpass it in height. By the seaside, and in situations much exposed to the wind, the Coco de Mer presents a somewhat barren aspect; its leaves being renewed so slowly are withered and rent, and the trees might be supposed to be dying. It has been observed that at the discovery of the islands which produce it, vast forests of the Coco de Mer existed. The height and smoothness of the trunks rendered it a less difficult matter to cut down a high tree than to climb it to obtain its fruit, and thousands have thus been wantonly destroyed, so that a few years ago hundreds of male trees might be found without a single female among them. Many fires have also occurred in these woods, and a vast number have been destroyed in the conflagrations which have taken place. Five or six years ago a fire broke out at Praslin, which continued for several weeks, blazing up again and again, after it was thought to be extinguished, and by this a very considerable number of these trees perished. On L'Ile Ronde not a plant remains. Curieuse, occupied as an establishment for the treatment of lepers, has a considerable number of fine young trees, and as this is government property, it is to be hoped that strict injunctions will be given to preserve every remaining tree, and also to plant others. If this be not done, it is not improbable that a few years hence this unique and interesting palm will no longer be found. The extremely slow growth has prevented most persons from planting it. There are not perhaps a score of trees in all the islands except Praslin and Curieuse. The growth of many young plants is stopped by cutting out the unopened leaves as fast as they appear, for the making of hats and other objects; these are called "Cocurs de Cocos," and are very pretty objects. The leaflets are so compactly packed together that they seem to form a solid mass as smooth as wax. Their edges are of a most beautiful delicate green, and the laminæ of a clear pale straw color. They form a material of unequaled quality for the making of hats and bonnets; and could they be supplied in sufficient quantity, a large trade might be carried on in them. A bonnet maker in London, who cleaned some bonnets for a lady from the Seychelles, was particularly struck with the excellence of the material of which they were made, and said she could insure a ready sale for any quantity of it. The splitting of the leaflets into strips of the desired breadth is a much more difficult affair than straw splitting, on account of the transverse fibers which traverse it. This operation is performed with considerable skill by those accustomed to it. They employ a simple little machine, made out of a piece of hard wood, with a sharp blade fixed in it. This blade is set at the required distance from a raised edge, which determines the width of the strip, and keeps it straight. The strips, however fine, can only be cut singly.

Very useful and pretty little baskets, called "sentes," are also made of these leaves; they last for many years, and by washing and bleaching may be always restored to their original color. It is cut out in various tasteful patterns, and made into fans which are much admired for their lightness and durability; artificial flowers are also made of it, which want nothing but color to be good imitations of nature. Work baskets, "corbeilles," of great beauty and in great variety, are made by the ladies of the Seychelles; and some of these productions obtained much admiration and a prize at the great exhibition of 1851. The nerve which strengthens each leaflet is employed to stiffen hats made of the leaf, each seam of the rows of plaits being sewn over it. This may also be split into fibers as fine as hair, and possessing considerable tenacity. I have seen a little basket of very complicated and delicate structure made of this material. It was manufactured by a lady of the Vendries family, which is unrivaled for the taste and skill displayed in the articles made from the Coco de Mer and its members. Mats of great beauty and unequaled durability are also made of these leaves. The extreme hardness and smoothness of their surface, and the length and strength of their fibers, are unrivaled by any substance within my knowledge. The expanded leaf forms an excellent thatch, nearly equal to shingles in durability; its strength is so great that when pinned together with little skewers of bamboo, it forms a basket capable of bearing nearly a bushel of fruit. The petiole

forms a strong and durable paling, and is also sometimes used for small rafters. The trunk, when cut into lengths, and split into palisades, is used instead of boards for the sides of houses, and will last I believe as long as any wood; when split in two, and hollowed, it is used for gutters for conveying water, and is almost imperishable. The size of the nuts varies greatly. I have seen some which would not hold a bottle, and others which were sixteen times as large; these extremes are rare, but a nut of ordinary size will hold from six to eight bottles.

When it is intended to preserve the shell entire, the nuts are left in a damp place, till the perisperm has rotted away, a process which requires many months to complete. While the kernel is decaying, it not unfrequently happens that flat-shelled snails introduce themselves into the nut, and grow too large to get out by the hole by which they entered; like the weasel in the fable, they die there. When the kernel is completely decayed, the shell is pierced with an auger at one end, or the extremity is sawn off; the orifice through which the germ sprouts is stopped up with a little pitch, and a withe round the cleft converts it into a convenient bucket, strong and light. When sawn longitudinally, it forms an elliptical vessel called "conscié," useful for many purposes, but superior to everything else for baling out boats.

Three-lobed nuts are sometimes met with. I have possessed one with five lobes, and have heard of one having as many as seven lobes. The kernel of the Lodoicea contains a portion of oil, but its excessive hardness, and the difficulty of detaching it from the shell, itself so valuable, render it practically useless for oil manufacture. The shell is about equal in hardness to that of the ordinary cocoanut, and equally susceptible of a fine polish; it is from a tenth to three-sixteenths of an inch in thickness. The foregoing simple account of the *Lodoicea Sechellarum* proves it to be a most interesting plant in a scientific point of view, and a very valuable one in an economical.

It is therefore well worthy of the attention of the government, as well as of private individuals, to use means not only to prevent its extinction, but also to favor its propagation.

CLEARING NEW LAND.*

By FRANKLIN WILLIAMS, JR.

THE clearing of new land is an important factor in the agricultural economics of many farms, yet prob-

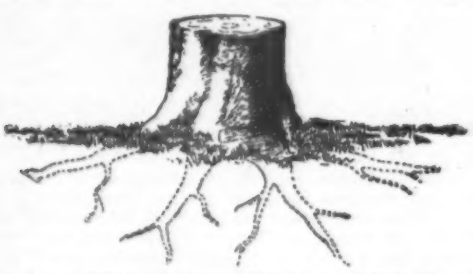


FIG. 1—SHOWING DYNAMITE CARTRIDGE IN POSITION.

ably no feature of farm life is so little understood and so blindly pursued. This unfortunate condition is largely due to lack of information upon the subject. Almost every other field of farm operations has been more or less thoroughly covered by agricultural publications of one kind or another; but the writer has long looked in vain for any definite and authentic information upon the subject of clearing land. The suggestions contained in this bulletin, being the results of practical work carried on for years, will, it is hoped, be of service to those who have land to clear.

For years the writer has been constantly engaged in clearing land, usually covered with bushes and timber of various sizes, including most species of forest trees common to the Middle Atlantic States. The task has been slow, laborious, and expensive, but very necessary.

Large Proportion of Uncleared Land.—The conditions indicated prevail upon thousands of American farms in the earlier settled portions of the country. Especially is this true in the South, where large areas once devoted to the cultivation of cotton and tobacco have through changed conditions inevitably gone to bush and small timber. The middle West is the only section of the country that does not need the woodman's ax and mattock. There woodland lots are at a premium. True, they have their heavy prairie sod to bring under subjection, but that does not compare with the task of making a way for the plow through brush and roots. The far West, however, has its share of bush land. The clearing of such tracts in that section has long been a regular occupation of Chinamen, who usually charge $18 to $20 per acre for such labor. New Englanders are not only annoyed by stones, but are frequently beset with scrub timber and old overgrown fields, yet it is in the South that the largest proportion of waste land is found. It is here that large farms with many wooded acres and only small parcels of cultivated land are seen. Throughout the South the proportion of bush and scrub timber land is astonishingly and deplorably large.

Importance of Clearing Land.—Land of this bushy character is neither tillable nor suitable for timber purposes. It is an eyesore to the community and an expense to the owner. It has no earning capacity. It is deadheading its way, and the day leads only to the impoverishment of the owner. If there is no intention of improving such land it would be wise to dispose of it. Holding it for higher prices is invariably a losing game. Taxes and loss of interest on purchase money usually more than offset any increase in value.

There is a notion which obtains among many persons that the ownership of land imparts respectability.

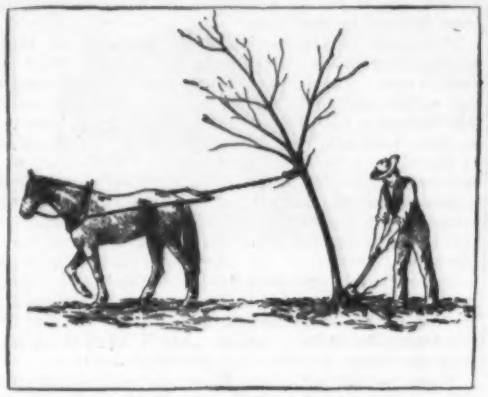


FIG. 2.—UPROOTING SAPLING WITH HORSE AND CHAIN.

The correctness of this idea is conditional. The possession of broad and productive acres, it is true, gives prestige as well as profit, but the ownership of nonproductive bushy land is discreditable. The character and thrift of the farmer may be justly estimated by the appearance of his land.

A good plan for the owner of unimproved land is to sell the surplus. Such a course will not only promote the owner's interest, but the common wealth of the community. "Loafer" land not only represents idle and taxable capital for the landlord, but the withholding of possible support from others.

If he is a benefactor of mankind who succeeds in making two blades of grass grow where only one grew before, how much more beneficent is the mission of making grass grow where only bushes were wont to thrive.

What Land Should Be Cleared.—The problem is not only how to clear overgrown land, but whether it will be profitable to do so. Manifestly much wooded land had better be left for timber and fuel purposes. Quantities of promising young timber are annually slaughtered. Indeed, the desecration of our forests amounts to almost a national calamity. Every farm should have its timbered tract, and that tract should be wisely conserved. The reckless use of an ax for a few hours will inflict damage that it will take nature years to repair.

Disposition of Farm Lands.—No field operation affords more opportunities for the exercise of intelligent discretion than farming, and no problem of farm life is more far-reaching in effects than the wise disposition of farm lands. To cut away young growth which would within reasonable time possess timber value is usually a mistake. To leave bush land idle when it will require a hundred years for it to develop into profitable timber is folly.

The timber consideration is not the only one that enters into the advisability of clearing land. The location of the tract, together with the density and size of the wooded covering, must be considered. The purpose for which the land is adapted and the probable income to be derived from it when cleared generally govern the advisability of clearing it. Yet it is desirable to open up the home site, connect fields, etc., at an expense greater than any probable pecuniary return would warrant. Farming has its æsthetic as well as its material consideration. The farmer who stops to figure whether an overgrown fence row would yield

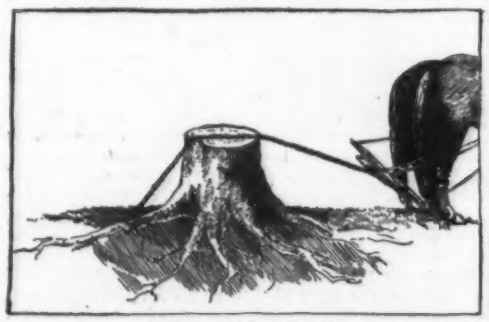


FIG. 3.—PULLING STUMP WITH CHAIN AND HORSES.

enough harvest to pay for its clearing will never have an attractive farm, or extract from farm life the pleasure it is capable of affording.

For Trucking or Orcharding.—It is obvious that it may be found profitable to clear land for trucking or orcharding when it would not be profitable to do so for general farm crops. In the former case a return of $100 or more per acre may reasonably be expected, while the gross income from an acre of grass or grain will rarely exceed $15 or $20.

Cost of Clearing.—In many sections farm improvements can be bought for less than cost. Certainly in such cases it is cheaper to purchase improved land than to buy impoverished or wooded tracts with a view to their improvement by clearing. If a living has to be earned upon it, poor or foul land is dear as a gift. Generally the expense of clearing will exceed the original cost of the land. The cost per acre will vary from $5 or $10 to $30 or $40, conditional on the kind, density and size of wooded covering. In many localities there is a fair demand for wood, the proceeds of which will help to defray the cost of clearing. In fact it might be profitable in some instances to dispose of the wood to the best advantage and then to give away, if it can not be sold, the land with all its stumps and roots and purchase improved land.

Fighting It Out with the Bushes.—However, this much can be said in favor of fighting it out with the bushes on one's own land. A farmer may improve his farm gradually as time and means permit, each year adding a few acres of cleared land. This small annual expenditure of time and means will scarcely be missed in the sum total of the year's accounts, yet in a short while it will make a most creditable showing. To thus gradually improve the land, is within the reach of all. And then there is a certain sentimental satisfaction in working out the salvation of one's own place. For who would not rather improve his own wooded hills and swampy bottoms than exchange them for the fields of another? The love of one's native place is happily a virtue that most men possess.

If for any reason it is decided to clear land, then the method to be employed becomes all important.

Methods of Clearing.—Pasturing.—In adopting a method of clearing one must be governed by various circumstances. For instance, if the wooded tract is adapted to pasture and stock are available, pasturing would undoubtedly be the cheapest means. If the timber consists of kinds that rot readily, it would be wise to simply cut away the wood and leave stumps and roots to decay for several years before attempting to cultivate. If the wooded growth is small, the mattock will usually prove the most satisfactory and expeditious means of removing the brush. Thus not only the location but the size and kind of timber enter into the problem of determining the wisest means for its destruction.

FIG. 4.—REMOVING STUMP WITH TRIPLE BLOCK AND ROPE.

Nature of Ground to be Considered.—The nature of the soil is the next thing to be considered. For instance, if soft or marshy the use of heavy machinery would be impracticable, and if stones are thickly embedded in it great difficulty would be experienced in keeping mattocks sharp. Whether the land is desired for immediate cultivation and a good yield is expected the first year or not, are also matters for consideration. It is evident that the wisest method to be pursued depends upon local conditions.

Clearing by Pasturing.—When circumstances permit, pasturing is undoubtedly the most economical way of clearing land. In fact, if the growth is large and the clearing is to be a profitable investment, pasturing is probably the best method that can be pursued.

The purpose of this method is to change the field from woodland to pasture and from pasture to cultivated ground. The stock will keep down new growth while stumps and roots decay.

Timber should be Cut Low.—In pursuing this course the timber should be cut low, leaving the stumps in the most favorable condition for rotting. The bush and trash should be burned. The stock ought to be allowed the run of only so large a tract as they can keep pretty well subdued. The quantity of sprouts and young bushes an animal will nip off will depend upon whether or not it has access to other vegetable matter.

It is desirable in late summer to go over the pasture lot and with an old ax remove the sprouts and bushes which the stock have failed to subdue. If this method is carefully followed for a few years, surprising results will follow. When the stumps of one tract are dead and decaying, another lot should be added to the pasture.

Sheep and goats are preferable, but any kind of stock is suitable for this kind of pasturing. Horses and cattle, and even hogs, will answer well for this purpose.

The Angora Goat as a Land Clearer.—Recently the Angora goat has attracted considerable attention as a land clearer. While other animals upon new land will usually confine their browsing to buds and tender shoots, and then largely for want of something better, the Angora prefers brush to grass. It will not only eat leaves and tender sprouts, but it will bark bushes and saplings whose tops it can not reach. This girdling is very destructive to vegetable life. In the far

* Farmers' Bulletin issued by the Department of Agriculture.

West, especially in the States of Washington and Oregon, this goat is frequently used as a means for clearing brush-land. Where there are large tracts to clear, goat grazing is probably the cheapest and most satisfactory method to pursue.

Those desiring further information about the Angora goat are referred to Farmers' Bulletin No. 137, U. S. Department of Agriculture, or Bulletin No. 27, Bureau of Animal Industry of that Department.

It is wiser, however, in most instances, to use what stock and means we have at hand, as the value of land in most regions is not sufficient to justify unusual expense in its improvement.

Clearing by Cutting away Timber.—It is recorded of the ostrich that when frightened it will burrow its head in the sand and imagine that it is hidden from the outside world because its own view is shut off. So is it with men who cut away and burn the brush and imagine that they have cleared the land because it looked clean. This is usually a mistake. Such land is untillable, and from each stump a number of sprouts will start and soon innumerable new bushes will be making headway. In a few years the land so recently apparently cleared will be more unsightly and expensive to clear than it was originally. Of course if it is practicable to remove immediately all starting sprouts the stumps must soon die. All vegetation requires leaves as well as roots to survive.

Timber Should Be Cut in Late Summer.—If, however, the cutting is relied upon it is wise to do it in late summer. In clearing hardwood it will not do to cut off and wait for stumps to decay; they should be immediately removed or some method pursued that will at least keep down the sprouts and prevent objectionable plant growth.

Usually in clearing land, as in everything else, that policy is best which leaves a finished work.

Clearing Pine Land.—However, in clearing most pine land the cutting method is the most expedient. The pine genus, excepting two or three species, is happily peculiar. Contrary to the rule in forestry, when the pine is cut off just above ground it does not throw up shoots. Consequently it soon dies, and if the stump be small it rapidly decays.

Many pine lands throughout the South may be cut off and safely left idle for several years with assurance the roots and stumps will rot. The white pine is the chief exception to this rule. Pine soil is not so impregnated with objectionable growth in an embryo state, waiting for an opportunity to develop into bushes, as is hard-wood land.

This non-sprouting characteristic of the stump of most species of pine, together with the relative freedom of pine soils from foul growth the first years, render Southern pine land comparatively easy and inexpensive to clean, especially if the timber is not large. New pine land is much more amenable to cultivation than lands from which other kinds of timber have been removed by cutting. This is owing to the semi-taproot system of the pine and the brittle nature of its roots.

Yellow Poplar.—The yellow poplar or tulip tree (*Liriodendron tulipifera*) is another tree species which, for purposes of clearing, should be classed with the pine. The rapidity with which the stumps and roots of this tree rot renders the cutting method of clearing land an eminently wise one in disposing of this member of the forest family. Unlike the pine, however, the poplar stump will send up numerous and vigorous shoots. Hence these should be sprouted off or grazed back, and then in a few years the stump, however large, will be a crumbled mass of vegetable mold.

There are other species of trees which resemble the pine and poplar in the susceptibility of their stumps to decay, and to which the cutting method is consequently applicable. Large areas of Southern river lands have cottonwood, soft maple (red or water maple), and sycamore, all of which rot fast, though the sycamore has great vitality. But these two species—the pine and yellow poplar—sufficiently illustrate the principle, and in the destruction of these the writer has served a full apprenticeship.

Alder.—Before leaving the discussion of this method of clearing, it might be well to briefly advert to the alder. It is usually found in dwarf-bush size and in clusters. Its habitat is lowlands and swampy bottoms. It is master of the land upon which it thrives, and its masses of interlocked roots present an impregnable obstacle to cultivation; yet, if its vulnerable points are understood it may be quickly and easily disposed of. In August, cut the alders off at or below the crown, leaving the brush where it falls. The following spring, after vegetation has started and the ground is thoroughly dry, burn the area over. If the cutting and burning have been thorough, the alders will never return to plague you. The next year the ground may be cultivated with comparative ease.

Clearing with Dynamite.—Dynamite for Large Stumps.—In the removal of large stumps dynamite is serviceable and economical. While it will seldom blow the stump out of the ground, it will usually split it in several parts and lay bare the roots, thus enabling the grubber to take out the stump piece by piece, which is less laborious than removing the whole stump. When occasional stumps are scattered over the field or plantation, along the roadway, or near the buildings, their immediate removal is desirable and for this purpose dynamite is serviceable.

Too Expensive for General Use.—The cost of this explosive will not justify its use on stumps under 6 or 8 inches in diameter. It is too expensive for general use in clearing land. While it is undoubtedly the cheapest method for removing stumps of large size, it is a question whether it is advisable for general farming to clear land covered with many such stumps. The profits in such farming are not certain enough or large enough to warrant heavy expense in bringing new land under cultivation. When much of the timber is over 6 or 8 inches in diameter at the base, and pasturing can not be conveniently resorted to, it is usually wise to utilize land so encumbered for its timber purposes.

The cost of dynamite will approximately vary from 10 to 20 cents per stump. It is readily seen that if

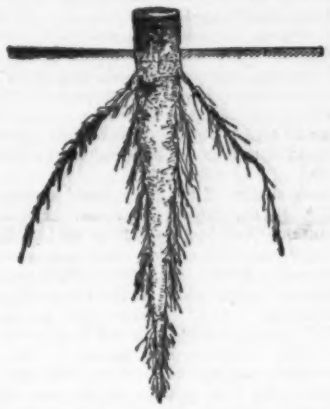


FIG. 5.—STUMP WITH TAPROOT.

there are some hundreds of these per acre the cost will be too great to justify clearing by this method land destined for general farming.

Experienced Hands Should be Employed.—When using dynamite great caution must be observed, for it is very dangerous if carelessly handled. Also, if placed by inexperienced hands, much of it is likely to be misapplied. Hence, if contemplating its use, it will be safer and cheaper to employ experienced help.

As a warning to those handling this explosive, it might be well to state that dynamite consists of nitroglycerin mixed with a granular absorbent, and wherever there is nitroglycerin there is danger. It is made in different grades. These are determined according to the percentage of nitroglycerin they contain. The lower grades, those containing about 30 per cent of nitroglycerin, are preferable for stump blasting because they explode with less suddenness and their tendency is more to upheave than to shatter.

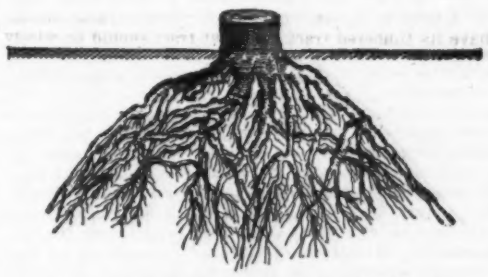


FIG. 6.—STUMP WITH SEMI-TAPROOT.

Dynamite comes in cylindrical sticks of different sizes and lengths. The quantity to use in blowing out a stump depends necessarily upon the size of the stump. The charge, with a cap and fuse attached, should be placed in a hole bored for the purpose as nearly as possible under the stump. The hole should then be filled with earth and gently tamped. Then the fuse may be lighted and the operator retreat beyond the range of flying fragments.

It is generally conceded by those familiar with dynamite that the most effectual destruction of the stump is achieved by boring into it as low down as possible, thus adding considerably to the force of the explosion (see Fig. 1). This method, however, adds to the time and labor and hence to the cost per stump, while the more common method of digging down by the side of the stump and hollowing out a place under it where the charge is placed will generally split up the stump sufficiently to make its removal an easy matter.

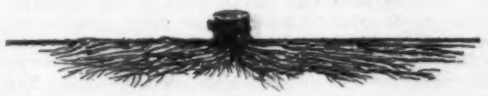


FIG. 7.—STUMP WITH LATERAL ROOTS.

Clearing with Machinery.—Stump-pulling Machinery.—There are many different makes of stump-pulling machinery upon the market. The promoters of these various grubbing devices claim great merit for their respective machines, but catalogue claims should be accepted with great caution.

In the neighborhood of the writer, and doubtless in many other neighborhoods, can be found such machinery in idleness because it was tested and found wanting. The difficulty with most stump-pulling machines is that if they are strong enough for the work desired of them they are too expensive, cumbersome and unwieldy.

When these machines are once properly adjusted, their work, provided nothing breaks, will be satisfactory. But the labor of moving and the care of adjusting, together with the liability to breakage, more than outweigh the virtues of any stump-pulling machine known to the writer. Moreover, usually, when the timber is large enough and thick enough to suggest recourse to machinery for clearing, it will not pay to clear such land at all unless it can be devoted to some specially profitable crop.

However, it may be said of machinery cleared land that the clearing is thorough. The machine removes practically all the roots of any size from the ground, leaving the land in a good tillable condition.

When it is the intention to use a machine the timber should be cut away and removed and the brush burned. Such preparatory work will greatly facilitate the moving and operation of the machine. The stumps should be left high enough to conveniently loop with a chain, for it is much easier to get a secure hold above than below ground.

Best Time to Operate a Machine.—The best time to operate a machine is immediately after a heavy thaw or rain. The stumps will draw much easier when the ground is soft and loose than when it is dry and hard.

Clearing with Horses and Chain.—Pulling up Saplings.—This method consists in pulling the young trees out of the ground. Where conditions are favorable it is surprising how rapidly this may be accomplished. The best results can be obtained where the growth consists of saplings, say 2 to 4 inches in diameter, which have a lateral root system such as possessed by the locust, maple, or dogwood. The ground should be soft and loose. The plan is simple. It consists in fastening one end of a long log chain to the trunk of the sapling as high above the ground as the flexibility of the tree will permit and hitching a steady horse, or, if necessary, a team of horses (see Fig. 2) to the other end of the chain. While the horses are pulling at the tree a man should be at its base with an ax and assist them by severing such roots as seem loath to give away.

Good and Fast Work.—In this manner, when the saplings are of the right size and kind, the ground in proper condition, the horses true and steady, the man with the ax alert and discreet, wonderfully good and fast work can be accomplished.

Stumps may also be pulled up with chain and horses. One end of a log chain should be fastened around one of the large roots of a stump, a team of horses being hitched to the other end. The chain is placed across the top of the stump which acts as a fulcrum and furnishes leverage for its own removal. (See Fig. 3.)

Clearing with Oxen.—A method in use at the Alaska Experiment Stations is thus described by Prof. C. C. Georgeson, special agent in charge of those stations, in his annual report for 1901:

"It has been our policy to gradually extend the clearing of land when time could be spared from other work. The timber is small and the task is not a difficult one, but the stumps are numerous, and it became necessary to devise some plan by which they could be pulled rapidly. The roots do not grow deep and it does not take great power to pull the average stump. A machine which was set up over the stump and worked by hand was first tried, but it proved to be too slow work, and it was too cumbersome to move. As a cheap and efficient means to aid in this work, I devised a simple stump-pulling tackle, consisting of two triple blocks and 300 feet of 1-inch rope. One block is attached to a solid stump and the other is attached to the stump it is desired to pull. When secured in this way the oxen are hitched to the rope and driven up slowly, and the stump usually comes out without trouble. The method of using this tackle is illustrated in Fig. 4. Two men and a yoke of oxen pulled six stumps in fifty minutes while I was there. I mention this fact only to show that it is a simple and efficient machine.

"The illustration shows the method of attachment when the stumps are cut high, or when they are very small. When the stumps are 12 inches in diameter, or when cut low so as to afford no leverage, we use a device of two timbers about 6 feet high, fastened together in the form of a letter A. To the top of this A is attached a chain or wire rope some 4 or 5 feet long and terminating in a hook. The A leans against one side of the stump and the hook is attached to a large root on the other side. The power is then applied to the top of the A, and as this is raised up the stump is tilted over. The device simply affords greater leverage than when the block is secured directly to the stump, as shown in the illustration."

Other Methods of Clearing.—Clearing with Mattock.—The mattock is king of new ground tools. No other instrument is so widely or satisfactorily used for grubbing. Wherever there are bushes the farm equipage is incomplete without its quota of mattocks in good condition. This tool is the most simple and convenient of all clearing implements.

Gradual Clearing.—In most instances economy and convenience require that clearing be done gradually, an acre or two being added each year. For such work the mattock is undoubtedly the most economical and best adapted. When a large tract is to be cleared without intermission, then other methods may be more suitable.

It is not generally advisable to cut off timber with a view to grub out the stumps afterward. It is much easier to grub the standing timber than the stumps after the trunk and tops have been severed, for it is the tap roots that are most inaccessible and difficult

to reach and cut, and the tops, by serving as a lever, greatly assist in loosening these.

Removal by Wind and Rain.—In the removal of trees of considerable size much labor may be saved by digging a trench immediately around the base of the tree, cutting all the laterals, and leaving the tap roots for the action of rain and wind. Water will collect in the trench and soften the subsoil and the wind with its swaying force will soon throw the tree. Indeed, when the side roots and the earth have been removed from around a tree, the prying force which the top will exercise upon the remaining roots will be irresistible. Each drop of rain and each puff of wind will contribute toward loosening and breaking those tap roots, which on account of their position almost defy the mattock. The assistance which nature is capable of affording in clearing away trees is wonderful. The spring season, when the ground is loose, the rains heavy, and the winds strong, is the most opportune time to pursue the above method.

Use Sharp Tools.—If a new mattock is needed do not be too economical to purchase it, and if it is dull do not imagine that you have not time to sharpen it. With a worn or dull hoe a man will pound more life out of himself than out of the bushes. A good plan is to have two hoes for each grubber, always keeping one in good condition. For sharpening hoes there is nothing so satisfactory as a steel file 12 or 16 inches in length.

Do not attempt too much continuous grubbing. It is very laborious work, and men will soon tire of it and become discouraged. A fatigued, disheartened laborer is never a success.

Grubbing at Intervals.—Plan to do some weeks of grubbing in the fall before winter sets in, continue it from time to time through the winter as weather permits, and follow it up in the spring with a few weeks more. In this manner a good deal can be accomplished without overtaxing your men at any one time.

Grubbing is slow and expensive, but when the land is needed it is time and means well spent. No farm is well ordered where there are foul fields and overgrown fence rows. No farmer commands the esteem of his neighbors when bushes are everywhere encroaching upon him.

Bush land is yielding no income. It is a boarder, and the owner pays the board bill in the shape of taxes, while the land is depreciating because it is growing all the time more expensive to clear.

Methods of Clearing Conditioned upon Character of Growth.—Variation of Root Systems.—There is a marked variation in the root systems of different species of trees. The roots of some strike deep into the ground, while others extend out laterally; and still others traverse the ground in every direction. Some varieties are much more persistent in renewing themselves than others. The stumps of some kinds will survive for years, while those of other species will soon decay.

It is obvious that these varying characteristics of root and stump must affect the method of dealing with the different species of trees.

Classification of Trees according to Root Characteristics.—In the United States there are about 500 species of indigenous forest trees. It would be beyond the limits and requirements of this article to attempt anything like a complete classification of all these numerous species. For our purpose we may classify trees according to their root characteristics and the durability of their stumps. To illustrate, we will indicate a number of a pronounced type belonging to these several classes.

Trees with a Taproot System.—The hickory, black gum, and white oak will represent this system. They have a typical taproot. (See Fig. 5.) Indeed, so pronounced are these characteristics that the root frequently holds its full trunk size for several feet under ground. Sometimes these large taproots break up into several smaller ones, but they invariably pursue a deep course downward. They send out to the side numerous small feeders, but exceptionally a lateral root of much size.

Cultivation around Stumps.—This is evidenced by the facility with which cultivation may be carried on around stumps having this root character. In plowing new ground the plowman is surprised to find with what ease he may pass some stumps, while it is necessary for him to bear his plow out of the ground or fight his way through a maze of roots as he approaches stumps of another species. Still further evidence of the varying root character of trees is manifested by the ability of some species to withstand wind storms, while others easily succumb. The forest may be full of uprooted trees, but the hickory, black gum, and white oak stand erect, resisting the force of wind and the ravages of time, until age has caused them to decay and crumble back to earth.

Stumps Difficult to Remove.—The taproot system of such trees makes it exceedingly difficult to remove their stumps. Roots of this character are very inaccessible to the mattock and resistant to force, whether applied by machinery or explosives. Hence, in clearing land covered with timber possessing this root system, either the method of pasturing or cutting back and cultivating should be pursued. The comparative ease with which the farmer may cultivate among stumps of this character and the extraordinary labor required to remove them, unite in suggesting the pursuance of one or the other of these methods.

Trees with a Semi-Taproot System.—This system embraces that numerous class of trees which throw out their roots in every direction. (See Fig. 6.) The pines, poplars, and chestnuts are good specimens of this system and are widely distributed. In many sections of the Eastern States trees of this kind largely predominate upon most wooded areas. Not only does this class include the largest number of trees, but also the greatest number of species.

Stumps with a semi-taproot system are not as expensive to remove as those with the system previously described; but, on account of their surface root, plowing among them is much more difficult. However, removing stumps of this class is an unthankful and laborious task.

Trees with a Lateral Root System.—The varieties of this kind are much less numerous than those of the preceding classes. It embraces all trees whose roots are of a distinct surface character. (See Fig. 7.) The elms, soft maple, locust, dogwood, and alder are representatives of this class. These species do not always attain the size of trees, but their roots invariably belong to the lateral system. In fact, their roots all extend immediately upon or just under the earth's surface.

It is exceedingly difficult to plow among stumps having this lateral system of roots. Practically all their roots are within the reach and path of the plow. Happily, stumps of this class are comparatively easy to remove. Their roots are readily accessible to the mattock, or easily yield to the force of machinery or explosives.

(To be continued.)

[Concluded from SUPPLEMENT No. 1601, page 25655.]

THE INCREASE OF KNOWLEDGE IN THE SEVERAL BRANCHES OF SCIENCE.*

By PROF. E. RAY LANKESTER, M.A., LL.D., D.Sc., F.R.S., F.L.S.

THE attempt to resuscitate Lamarck's views on the inheritance of acquired† characters has been met not only by the demand for the production of experimental proof that such inheritance takes place, which has never been produced, but on Weismann's part by a demonstration that the reproductive cells of organisms are developed and set aside from the rest of the tissues at so early a period that it is extremely improbable that changes brought about in those other tissues by unaccustomed incident forces can be communicated to the germ-cells so as to make their appearance in the offspring by heredity. Apart from this, I have drawn attention to the fact that Lamarck's first and second laws (as he terms them) of heredity are contradictory the one of the other, and therefore may be dismissed. In 1894 I wrote:

"Normal conditions of environment have for many thousands of generations molded the individuals of a given species of organism, and determined as each individual developed and grew 'responsive' quantities in its parts (characters); yet, as Lamarck tells us, and as we know, there is in every individual born a potentiality which has *not* been extinguished. Change the normal conditions of the species in the case of a young individual taken to-day from the site where for thousands of generations its ancestors have responded in a perfectly defined way to the normal and defined conditions of environment; reduce the daily or the seasonal amount of solar radiation to which the individual is exposed; or remove the aqueous vapor from the atmosphere; or alter the chemical composition of the pabulum accessible; or force the individual to previously unaccustomed muscular effort or to new pressures and strains; and (as Lamarck bids us observe), in spite of all the long-continued response to the earlier normal specific conditions, the innate congenital potentiality shows itself. The individual under the new quantities of environing agencies shows *new* responsive quantities in those parts of its structure concerned, new or *acquired* characters.

"So far, so good. What Lamarck next asks us to accept, as his 'second law,' seems not only to lack the support of experimental proof, but to be inconsistent with what has just preceded it. The new character which is *ex hypothesi*, as was the old character (length, breadth, weight of a part) which it has replaced—a response to environment, a particular molding or manipulation by incident forces of the potential congenital quality of the race—is, according to Lamarck, all of a sudden raised to extraordinary powers. The new or freshly acquired character is declared by Lamarck and his adherents to be capable of transmission by generation; that is to say, it alters the potential character of the species. It is no longer a merely responsive or reactive character, determined quantitatively by quantitative conditions of the environment, but becomes fixed and incorporated in the potential of the race, so as to persist when other quantitative external conditions are substituted for those which originally determined it. In opposition to Lamarck, one must urge, in the first place, that this thing has never been shown experimentally to occur; and in the second place, that there is no ground for holding its occurrence to be probable, but, on the contrary, strong reason for holding it to be improbable. Since the old character (length, breadth, weight) had not become fixed and congenital after many thousands of successive generations of individuals had developed it in response to environment, but gave place to a new character when new conditions operated on an individual (Lamarck's first law), why should we suppose that the new character is likely to become fixed after a much shorter time of responsive existence, or to escape the operation of the first law? Clearly there is no reason (so far as Lamarck's statement goes) for any such supposition, and the two so-called laws of Lamarck are at variance with one another."

In its most condensed form my argument has been stated thus by Prof. Poulton: Lamarck's "first law assumes that a past history of indefinite duration is powerless to create a bias by which the present can be controlled; while the second assumes that the brief history of the present can readily raise a bias to control the future."*

An important light is thrown on some facts which seem at first sight to favor the Lamarckian hypothesis by the consideration that, though an "acquired" character is not transmitted to offspring as the consequence of the action of external agencies determining the "acquirement," yet the tendency to react exhibited by the parent *is* transmitted, and if the tendency is exceptionally great a false suggestion of a Lamarckian inheritance can readily result. This inheritance of "variation in tendencies to react" has a wide application, and has led me to coin the word "educability" as mentioned in the section of this address on Psychology.

The principle of physiological selection advocated by Dr. Romanes does not seem to have caused much discussion, and has been unduly neglected by subsequent writers. It was ingenious, and was based on some interesting observations, but has failed to gain support.

The observations of de Vries—showing that in cultivated varieties of plants a new form will sometimes assert itself suddenly and attain a certain period of dominance, though not having been gradually brought into existence by a slow process of selection—have been considered by him, and by a good many other naturalists, as indicating the way in which new species arise in nature. The suggestion is a valuable one if not very novel, but a great deal of observation will have to be made before it can be admitted as really having a wide bearing upon the origin of species. The same is true of those interesting observations which were first made by Mendel, and have been resuscitated and extended with great labor and ingenuity by recent workers, especially in this country by Bateson and his pupils. If it should prove to be true that varieties when crossed do not, in the course of eventual inter-breeding, produce intermediate forms as hybrids, but that characters are either dominant or recessive, and that breeds result having pure unmixed characters—we should, in proportion as the Mendelian law is shown to apply to all tissues and organs, and to a majority of organisms, have before us a very important and determining principle in all that relates to heredity and variation. It remains, however, to be shown how far the Mendelian phenomenon is general. And it is, of course, admitted on all sides that, even were the Mendelian phenomenon general and raised to the rank of a law of heredity, it would not be subversive of Mr. Darwin's generalizations, but probably tend to more ready application of them to the explanation of many difficult cases of the structure and distribution of organisms.

Two general principles which Mr. Darwin fully recognized appear to me to deserve more consideration and more general application to the history of species than he had time to give to them, or than his followers have accorded to them. The first is the great principle of "correlation of variation," from which it follows that, while natural selection may be favoring some small and obscure change in an unseen group of cells—such as digestive, pigmentary or nervous cells, and that change a change of selective value—there may be, indeed often is, as we know, a correlated or accompanying change in a physiologically related part of far greater magnitude and prominence to the eye of the human onlooker. This accompanying or correlated character has no selective value, is not an adaptation—is, in fact, a necessary but useless by-product. A list of a few cases of this kind was given by Darwin, but it is most desirable that more should be established. For they enable us to understand how it is that specific characters, those seen and noted on the surface by systematists, are not in most cases adaptations of selective value. They also open a wide vista of incipient and useless developments which may suddenly, in their turn, be seized upon by over-watchful natural selection and raised to a high pitch of growth and function.

The second, somewhat but by no means altogether neglected, principle is that a good deal of the important variation in both plants and animals is not the variation of a minute part or confined to one organ, but has really an inner physiological basis, and may be a variation of a whole organic system or of a whole tissue expressing itself at several points and in several shapes. In fact, we should perhaps more generally conceive of variation as not so much the accomplishment and presentation of one little mark or difference in weight, length, or color, as the expression of a *tendency to vary* in a given tissue or organ in a particular way. Thus we are prepared for the rapid extension and dominance of the variation if once it is favored by selective breeding. It seems to me that such cases as the complete disappearance of scales from the integument of some osseous fishes, or the possible retention of three or four scales out of some hundreds present in nearly allied forms, favor this mode of conceiving of variation. So also does the marked tendency to produce membranous expansions of the integument in the bats, not only between the digits and from the axilla, but from the ears and different regions of the face. Of course, the alterna-

* Presidential address delivered to the British Association for the Advancement of Science.

† I use the term "acquired" without prejudice in the sense given to that word by Lamarck himself.

* Nature, vol. li., 1894, p. 127.

tive hairy or smooth condition of the integuments both in plants and animals is a familiar instance in which a tendency extending over a large area is recognized as that which constitutes the variation. In smooth or hairy varieties we do not postulate an individual development of hairs subjected one by one to selection and survival or repression.

Disease.—The study of the physiology of unhealthy, injured or diseased organisms is called pathology. It necessarily has an immense area of observation and is of transcending interest to mankind who do not accept their diseases unresistingly and die as animals do, so purifying their race, but incessantly combat and fight disease, producing new and terrible forms of it, by their willful interference with the earlier rule of nature.

Our knowledge of disease has been enormously advanced in the last quarter of a century, and in an important degree our power of arresting it, by two great lines of study going on side by side and originated, not by medical men nor physiologists in the narrow technical sense, but by naturalists, a botanist, and a zoologist. Ferdinand Cohn, professor of botany in Breslau, by his own researches and by personal training in his laboratory, gave to Robert Koch the start on his distinguished career as a bacteriologist. It is to Metschnikoff the zoologist and embryologist that we owe the doctrine of phagocytosis and the consequent theory of immunity now so widely accepted.

We must not forget that in this same period much of the immortal work of Pasteur on hydrophobia, of Behring and Roux on diphtheria, and of Ehrlich and many others to whom the eternal gratitude of mankind is due, has been going on. It is only some fifteen years since Calmette showed that if cobra poison were introduced into the blood of a horse in less quantity than would cause death, the horse would tolerate with little disturbance after ten days a full dose, and then day after day an increasing dose, until the horse without any inconvenience received an injection of cobra poison large enough to kill thirty horses of its size. Some of the horse's blood being now withdrawn was found to contain a very active antidote to cobra poison—what is called an antitoxin. The procedure and preparation of the antitoxin is practically the same as that previously adopted by Behring in the preparation of the antitoxin of diphtheria poison. Animals treated with injections of these antitoxins are immune to the poison itself when subsequently injected with it, or, if already suffering from the poison (as, for instance, by snake-bite), are readily shown by experiment to be rapidly cured by the injection of the appropriate antitoxin. This is, as all will admit, an intensely interesting bit of biology. The explanation of the formation of the antitoxin in the blood and its mode of antagonizing the poison is not easy. It seems that the antitoxin is undoubtedly formed from the corresponding toxin or poison, and that the antagonism can be best understood as a chemical reaction by which the complex molecule of the poison is upset, or effectively modified.

The remarkable development of Metschnikoff's doctrine of phagocytosis during the past quarter of a century is certainly one of the characteristic features of the activity of biological science in that period. At first ridiculed as "Metschnikoffism," it has now won the support of its former adversaries.

For a long time the ideal of hygienists has been to preserve man from all contact with the germs of infection, to destroy them and destroy the animals conveying them, such as rats, mosquitoes, and other flies. But it has now been borne in upon us that, useful as such attempts are, and great as is the improvement in human conditions which can thus be effected, yet we cannot hope for any really complete or satisfactory realization of the ideal of escape from contact with infective germs. The task is beyond human powers. The conviction has now been arrived at that, while we must take every precaution to diminish infection, yet our ultimate safety must come from within—namely, from the activity, the trained, stimulated, and carefully guarded activity, of those wonderful colorless amœba-like corpuscles whose use was so long unrecognized, but has now been made clear by the patiently continued experiments and arguments of Metschnikoff, who has named them "phagocytes." The doctrine of the activity and immense importance of these corpuscles of the living body which form part of the all-pervading connective tissues and float also in the blood, is in its nature and inception opposed to what are called the "humoral" and "vitalistic" theories of resistance to infection. Of this kind were the beliefs that the *liquids* of the living body have an inherent and somewhat vague power of resisting infective germs, and even that the mere living quality of the tissues was in some unknown way antagonistic to foreign intrusive disease-germs.

The first eighteen years of Metschnikoff's career, after his undergraduate course, were devoted to zoological and embryological investigations. He discovered many important facts, such as the alternation of generations in the parasitic worm of the frog's lung —*Ascaris nigrovenosa*—and the history of the growth from the egg of sponges and medusæ. In these latter researches he came into contact with the wonderfully active cells, or living corpuscles, which in many low forms of life can be seen by transparency in the living animal. He saw that these corpuscles (as was indeed already known) resemble the well-known amœba, and can take into their soft substance (protoplasm) at all parts of their surface any minute particles and digest them, thus destroying them. In a transparent water-flea Metschnikoff saw these amœba-like, colorless, floating blood-corpuscles swallowing and digesting the spores of a parasitic fungus which had attacked the water-fleas and was causing their death. He came to the conclusion that this is the chief, if not the whole, value of these corpuscles in higher as well as lower animals, in all of which they are very abundant. It was known that when a wound bringing in foreign matter is inflicted on a vertebrate animal the blood-vessels become gorged in the neighborhood and the colorless corpuscles escape through the walls of the vessels in crowds. Their business in so doing, Metschnikoff showed, is to eat up the foreign matter, and also eat up and remove the dead, wounded tissue. He therefore called these white or colorless corpuscles "phagocytes," the eater-cells, and in his beautiful book on inflammation published twenty years ago, proved the extreme importance of their activity. At the same time he had shown that they eat up intrusive bacteria and other germs; and his work for the last twenty years has mainly consisted in demonstrating that they are the chief, and probably the only, agents at work in either ridding the human body of an attack of disease-causing germs or in warding off even the commencement of an attack, so that the man or animal in which they are fully efficient is "immune"—that is to say, cannot be effectively attacked by disease-germs.

Disease-germs, bacteria, or protozoa produce poisons which sometimes are too much for the phagocytes, poisoning them and so getting the upper hand. But, as Metschnikoff showed, the training of the phagocytes by weak doses of the poison of the disease-germ, or by weakened cultures of the disease-germ itself, brings about a power of resistance in the phagocytes to the germ's poison, and thus makes them capable of attacking the germs and keeping them at bay. Hence the value of inoculations.

The discussion and experiments arising from Metschnikoff's demonstrations have led to the discovery of the production by the phagocytes of certain exudations from their substance which have a most important effect in weakening the resistance of the intrusive bacteria and rendering them easy prey for the phagocyte. These are called "sensitizers," and have been largely studied. They may be introduced artificially into the blood and tissues so as to facilitate the work of the phagocytes, and no doubt it is a valuable remedial measure to make use of such sensitizers as a treatment. Dr. Wright considers that such sensitizers are formed in the blood and tissues independently of the phagocytes, and has called them "opsonins," under which name he has made most valuable application of the method of injecting them into the body so as to facilitate the work of the phagocytes in devouring the hostile bacteria of various diseases. Each kind of disease-producing microbe has its own sensitizer or opsonin; hence there has been much careful research and experiment required in order to bring the discovery to practical use. Metschnikoff himself holds and quotes experiments to show that the "opsonins" are actually produced by the phagocytes themselves. That this should be so is in accordance with some striking zoological facts, as I pointed out nearly twenty years ago. For the lowest multicellular animals provided with a digestive sac or gut, such as the polyps, have that sac lined by digestive cells which have the same amœboid character as "phagocytes," and actually digest to a large extent by swallowing or taking into their individual protoplasm raw particles of food. Such particles are inclosed in a temporary cavity, or vacuole, into which the cell-protoplasm secretes digestive ferment and other chemical agents. Now there is no doubt that such digestive vacuoles may burst and so pour out into the polyp's stomach a digestive juice which will act on food particles outside the substance of the cells, and thus by the substitution of this process of outpouring of the secretion for that of ingestion of food particles into the cells we get the usual form of digestion by juices secreted into a digestive cavity. Now this being certainly the case in regard to the history of the original phagocytes lining the polyp's gut, it does not seem at all unlikely, but on the contrary in a higher degree probable, that the phagocytes of the blood and tissues should behave in the same way and pour out sensitizers and opsonins to paralyze and prepare their bacterial food. And the experiments of Metschnikoff's pupils and followers show that this is undoubtedly the case. Whether there is any great variety of and difference between "sensitizers" and "opsonins" is a matter which is still the subject of active experiment. Metschnikoff's conclusion, as recently stated in regard to the whole progress of this subject, is that the phagocytes in our bodies should be stimulated in their activity in order successfully to fight the germs of infection. Alcohol, opium, and even quinine, hinder the phagocytic action; they should therefore be entirely eschewed or used only with great caution where their other and valuable properties are urgently needed. It appears that the injection of blood-serum into the tissues of animals causes an increase in the number and activity of the phagocytes, and thus an increase in their resistance toward pathogenic germs. Thus Durham (who was a pioneer in his observations on the curious phenomena of the "agglutination" of blood corpuscles in relation to disease) was led to suggest the injection of sera during surgical operations, and experiments recently quoted by Metschnikoff seem to show that the suggestion was well founded. Both German and French surgeons have employed the method with successful results, and the demonstration that an immense number of microbes are thus taken up and destroyed by the multiplication (due to their regular increase by cell-division) of the phagocytes of the injected patient. After years of opposition bravely met in the pure scientific spirit of renewed experiment and demonstration, Metschnikoff is at last able to say that the foundation-stone of the hygiene of the tissues—the thesis that our phagocytes are our arms of defense against infective germs—has been generally accepted.

Another feature of the progress of our knowledge of disease—as a scientific problem—is the recent recognition that minute animal parasites of that low degree of unicellular structure to which the name "Protozoa" is given, are the causes of serious and ravaging diseases, and that the minute algoid plants, the bacteria, are not alone in possession of this field of activity. It was Laveran—a French medical man—who, just about twenty-five years ago, discovered the minute animal organism in the red blood-corpuscles, which is the cause of malaria. Year by year ever since, our knowledge of this terrible little parasite has increased. We now know many similar to, but not identical with it, living in the blood of birds, reptiles, and frogs.

It is the great merit of Major Ross, formerly of the Indian Army Medical Staff, to have discovered, by most patient and persevering experiment, that the malaria parasite passes a part of its life in the spot-winged gnat or mosquito (*Anopheles*), not, as he at first supposed, in the common gnat or mosquito (*Culex*), and that if we can get rid of spot-winged mosquitoes or avoid their attentions, or even only prevent them from sucking the blood of malarial patients, we can lessen, or even abolish, malaria.

This great discovery was followed by another as to the production of the deadly "Nagana" horse and cattle disease in South Africa by a screw-like, minute animal parasite, the *Trypanosoma Brucei*. The Tsetze fly, which was already known in some way to produce this disease, was found by Col. David Bruce to do so by conveying by its bite the Trypanosoma from wild big-game animals to the domesticated horses and cattle of the colonists. The discovery of the parasite and its relation to the fly and the disease was as beautiful a piece of scientific investigation as biologists have ever seen. A curious and very important fact was discovered by Bruce—namely, that the native big game (zebras, antelopes, and probably buffaloes) are *tolerant* of the parasite. The Trypanosoma grows and multiplies in their blood, but does not kill them or even injure them. It is only the unaccustomed introduced animals from Europe which are poisoned by the chemical excreta of the Trypanosomes and die in consequence. Hence the wild creatures—brought into a condition of tolerance by natural selection and the dying out of those susceptible to the poison—form a sort of "reservoir" of deadly Trypanosomes for the Tsetze flies to carry into the blood of new-comers. The same phenomenon of "reservoir-hosts" (as I have elsewhere called them) has since been observed in the case of malaria; the children of the native blacks in Africa and in other malarious regions are *tolerant* of the malarial parasite, as many as eighty per cent of children under ten being found to be infected, and yet not suffering from the poison. This is not the same thing as the immunity which consists in *repulsion* or *destruction* of the parasite.

The Trypanosomes have acquired a terrible notoriety within the last four years, since another species, also carried by a Tsetze fly of another species, has been discovered by Castellani in cases of sleeping sickness in Uganda, and demonstrated by Col. Bruce to be the cause of that awful disease. Over 200,000 natives of Uganda have died from it within the last five years. It is incurable, and sad to relate, not only a certain number of European employees have succumbed to it in tropical Africa, but a brave young officer of the Army Medical Corps, Lieut. Tulloch, has died from the disease acquired by him in the course of an investigation of this disease and its possible cure, which he was carrying out, in association with other men of science, on the Victoria Nyanza in Central Africa. Lieut. Tulloch was sent out to this investigation by the Royal Society of London, and I will venture to ask you to join that body in sympathy for his friends, and admiration for him and the other courageous men who risk their lives in the endeavor to arrest disease.

Trypanosomes are now being recognized in the most diverse regions of the world as the cause of disease—new horse diseases in South America, in North Africa, in the Philippines and East India are all traced to peculiar species of Trypanosome. Other allied forms are responsible for Delhi-sore, and certain peculiar Indian fevers of man. A peculiar and ultra-minute parasite of the blood cells causes Texas fever, and various African fevers deadly to cattle. In all these cases, as also in that of plague, the knowledge of the carrier of the disease, often a mite or acarus—in that of plague the flea of the rat—is extremely important, as well as the knowledge of reservoir-hosts when such exist.

The zoologist thus comes into closer touch than ever with the profession of medicine, and the time has arrived when the professional students of disease fully admit that they must bring to their great and hopeful task of abolishing the diseases of man the fullest aid from every branch of biological science. I need not say how great is the contentment of those who have long worked at apparently useless branches of science, in the belief that all knowledge is good, to find that the science they have cultivated has become suddenly and urgently of the highest practical value.

I have not time to do more than mention here the effort that is being made by combined international research and co-operation to push further in our knowledge of phthisis and of cancer, with a view to their destruction. It is only since our last meeting at York that the parasite of phthisis or tubercle has been made known; we may hope it will not be long before we have

similar knowledge as to cancer. Only eighteen months have elapsed since Fritz Schaudinn discovered the long-sought parasitic germ of syphilis, the *Spirocheta pallida*. As I write these words the sad news of Schaudinn's death at the age of thirty-five comes to me from his family at Hamburg—an irreparable loss.

Let me finally state, in relation to this study of disease, what is the simple fact—namely, that if the people of Britain wish to make an end of infective and other diseases they must take every possible means to discover capable investigators, and employ them for this purpose. To do this, far more money is required than is at present spent in that direction. It is necessary, if we are to do our utmost, to spend a thousand pounds of public money on this task where we now spend one pound. It would be reasonable and wise to expend ten million pounds a year of our revenues on the investigation and attempt to destroy disease. Actually, what is so spent is a mere nothing, a few thousands a year. Meanwhile our people are dying by thousands of preventable disease.

RIFLED PIPE FOR CONDUCTING HEAVY CRUDE FUEL OIL.*

By JOHN D. ISAACS.

THE crude oil product of most of the California fields is a very heavy, thick, and viscous fluid with an asphalt base. The entire product of the Kern River fields, near Bakersfield, is particularly heavy, its density averaging about 14 deg. Baumé. Up to the present time this oil has been transported from the fields in cars, but attempts have been made to facilitate its movement by long pipe lines. These trials met with little success, as it was found necessary to use very high pumping pressures, necessitating expensive pipe and powerful pumping plants, located so close together that operating expenses were prohibitively high for practical economy, and even with such a system the delivery was very small. Various attempts have been made to overcome these difficulties; the most important of these is heating the oil. This was a decided help in short pipe lines, but a temperature sufficient to be effective for long-distance pumping caused the disintegration of the oil and the deposit of asphaltine, called by the oil men "carbonizing," clogging the line. Water was introduced with the oil, but as much as thirty per cent of water was needed to materially improve the results, and the surging of the mixture through the line soon caused an emulsion of the oil and water very difficult and expensive to separate, necessitating heating the oil to 180 deg. Fah. for this purpose. The mixing of the lighter oils with the heavy oil has made it possible to pump the mixture, but in the fields where only the heavy oils are obtained; this necessitates the pumping of the light oils to such fields from long distances, and the mixing of the oils causes a loss in the value of the light oils, which have a market value much higher than the heavy fuel oils, making this process very expensive.

A new process invented by the writer and Mr. Buckner Speed has been adopted by the Southern Pacific Company. This process is to rifle the pipe, giving it an interior appearance similar to that of a rifle barrel. A small percentage of water is pumped with the oil. The rifling of the pipe causes the entire liquid mass to whirl, and as the water is heavier than the oil, it is thrown to the exterior of the mass, causing the envelopment of the oil with a thin shell or film of water. This forms a water lubrication between the oil and the pipe, greatly reducing the friction and allowing the plug or core of oil to glide through the pipe readily.

When this principle was discovered, the first experiment was made with a small lead pipe. In the process of drawing ordinary lead pipe, the interior surface is slightly scored in close longitudinal lines. The pipe was first used as received and friction coefficients determined; it was then twisted by hand, causing these longitudinal scorings to become helical. This was sufficient to cause a rotation of the oil and water when passed through the pipe. Experiments made with this rifled lead pipe indicated the soundness of the principle, and led to an experiment on a larger and more practical scale. One-half mile of three-inch standard line pipe was used in the next experiment, which was performed by the Southern Pacific Company at West Oakland. The pipe was first rifled by the insertion of helical wires. This was accomplished by simply drawing tempered steel wire from a coil through the pipe in lengths of 500 feet at one time, the spring of the wire causing it to cling closely to the sides of the pipe, forming a helix. This pipe was then laid and subjected to an exhaustive experimental operation with heavy Kern oil. The best results were obtained by pumping about 10 per cent water with the oil. A flow was obtained many times that obtained by pumping pure oil, or oil and water, through an ordinary plain pipe. The three-inch line was then rifled (by passing the pipe through a series of rollers) to a pitch of 1.5 with the line of the pipe. Experiments on this line gave even better results and lower coefficients than those from the lead pipe, and justified the construction of a practical rifled pipe line for transporting oil commercially. A pipe line was finally constructed 31.17 miles long, between Volcan, a point located centrally in the oil fields, and on the Southern Pacific Company's railroad, and Delano, another station northward on the same railroad at an elevation of 120 feet below Volcan. The pipe used was standard eight-inch line pipe, weighing 28.2 pounds per foot, fitted with recessed line couplings and tested to 1,200 pounds per square inch.

RIFLED PIPE 3 INCHES IN DIAMETER.

RIFLING MACHINE FOR PIPE OF 5 TO 9 INCHES DIAMETER.

RIFLING MACHINE FOR PIPE VARYING IN DIAMETER FROM 1 INCH TO 4 INCHES.

The machine used for rifling the pipe is shown in the accompanying engraving; the two large disks carry six rollers each, mounted in roller fork bearings. The central disk is a floating disk, to which are attached wedges. These wedges taper outward on both sides of the disk, one wedge being opposite each roller fork, and engaging with the fork. When the three disks are apart, the rollers are open wide enough to allow a pipe coupling to pass freely between them. By means of pulling rods operated by a lever, the three disks are drawn together to any limit set by the adjustable stud bolts. This drawing together of the three disks causes the wedges to thrust the roller forks toward a common center, that is, indent them into the pipe to any desired length. The rollers were set at a pitch of about 1.5 with the line of the pipe. The disks are so spaced that each roller in one large disk lines up with the corresponding roller in the other, so that when the pipe is drawn through, it rotates one-sixth of a turn between the two disks. Thus, for one turn of the rifling in ten feet of pipe, the disks would be one-sixth of ten feet apart in the closed position, or twenty inches. The circumference of the pipe is about twenty-five inches, so the pitch of the rollers to correspond to one turn of rifling in ten feet would be as 25:120.

GENERAL VIEW OF THE RIFLING MACHINE.

Each length of pipe was fitted with a pulling plug on the male thread, having an air vent, and a testing plug on the coupling end by which water was introduced. The pipe was filled with water, the pressure raised to 1,200 pounds and then released. If the pipe stood the test satisfactorily, it was placed in the rifling machine. The rollers were closed just behind the pulling plug, the rollers indenting the pipe to a depth of three thirty-seconds of an inch. By means of a hoisting engine and a pair of triple blocks reeved with a seven-eighths inch steel cable, the pipe was drawn through the machine. The rollers described six helical paths around the pipe, one complete turn in each ten feet. The rollers were then opened, the pipe drawn out, and subjected to 1,200-pound water test. During the operation of the machine, the rollers were flooded with lubricating oil. The result was a pipe spirally indented, and having the appearance of being rifled when looked into at one end.

The line was now laid in a ditch to a depth of about two feet, and screwed together by four pairs of eight-inch lay tongs handled by sixteen men. The ditch was dug about eighteen inches wide, and the pipe laid zigzag within the easy elastic bending of the pipe to provide for expansion by heat. In the vertical plane, the pipe was also laid with a vertical zigzag or wave of about four hundred feet in length or shorter. The depth of these waves is about the diameter of the pipe, so as to form traps at 400-feet intervals. The object of the traps is to accumulate water at frequent intervals when the line is shut down, preventing the formation of a long plug of solid oil, and facilitating the restarting of the line.

The pumping station consists of three 200-horse-power boilers of the return tubular type fitted with water heater, duplicate feed pumps, and pressure burners. The main pump is a compound duplex steam pump, 25-inch and 42-inch steam cylinders with 9½-inch oil plungers with 36-inch stroke. The auxiliary water pump is a duplex plunger steam pump, 16-inch steam cylinders, 5-inch plungers, and 12-inch stroke. The oil supply tank is thirty feet higher than the pump and a 27-inch suction pipe used, about 100 feet long, insuring an ample supply for the pump. The water is injected by means of a special injection nozzle. A piece of seven-inch well casing was introduced inside the eight-inch pipe; oil passes through the inner pipe, and water is introduced through the annular space between the two pipes, both starting off in their proper relative position. A short baffle, or twisted plate, was placed in the inner tube at this point to give the oil an initial whirl.

The line was first tested with water, and all breaks and leaks repaired until the entire line held 1,000 pounds pressure. The line was next subjected to a continuous operating test, lasting twenty-four days. During this run an average of over 14,000 barrels net oil in twenty-four hours was obtained for the entire run at an initial pressure of 800 pounds per square inch. For several hours at various parts of the test over 675 barrels of net oil per hour was pumped at 800 pounds. The oil furnished was exceptionally heavy, and had stood for a long period in an earthern storage reservoir, so that much of its light constituents had evaporated. The temperature of the oil was all below 60 deg. Fah. when received at Delano, and in no case

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

was over 75 deg. Fah. when received at the pumping station, but it averaged much lower. Experiments show that the maximum flow of oil was obtained when about ten per cent of water was used.

A NEW EXCAVATING MACHINE.*

WITHIN recent years tunnels and subways as means of transportation and communication have taken so important a place in the engineering world—far more so than formerly—that excavating machinery has presented an alluring field for the inventor. Many devices have been produced to facilitate and accelerate the work of digging tunnels and ditches, and among the latest of these is an excavating machine invented by Mr. George W. Jackson. In general, this apparatus consists of a swinging arm carrying a revolving cutter with a plurality of blades at the forward end of the arm, and a supporting frame upon which the arm is pivoted. The supporting frame carries a pivot, the axis of which is substantially perpendicular to the pivotal axis of the swinging arm, and by means of this double pivoting it is possible to vary both the vertical and horizontal angles of presentation of the cutter as the circumstances require. The mechanism is mounted on a carriage, which is adapted to be moved forward on rails which are laid on the floor of the tunnel as the excavation advances.

The accompanying photographs are of a working model of Mr. Jackson's invention, showing the same from the rear and in front elevation. The horizontal carriage which supports the machine, and runs upon track rails of the usual kind, has longitudinal and transverse members which carry the mechanism. The swinging arm *A* is pivotally mounted at its rear end upon a supporting frame, and carries at its forward end the cutting device *B*. The supporting frame for the swinging arm comprises upright standards *C*, rising from the horizontal plate *D*, which, in turn, is carried on a horizontal platform formed at the upper end of a standard that constitutes part of a frame spanning the side members of the carriage. The horizontal plate *D* and the platform constitute parts of a turntable, the plate being pivotally mounted on a central vertical stud, which is seated in a recess formed for it in the standard carrying the platform.

The base-plate of the cutter-arm supporting frame

A NEW EXCAVATING MACHINE.

has a gear segment attached to it, which extends toward the rear part of the carriage. A gear pinion engages with this, and is mounted in the frame secured to the side members of the carriage. An operating wheel is mounted to the upper end of the vertical shaft which carries the gear pinion, and by means of it the supporting frame of the knife arm may be swung in a horizontal plane about the axis of the pivot stud of the turntable, in order to present the cutter at varying horizontal angles to the tunnel breast. The cutter arm is swung vertically by means of a worm gear segment outside of the standard, at the left-hand side of the machine, which engages with a worm gear mounted on a vertical shaft journaled on and extending laterally from the left-hand standard. A hand wheel upon this shaft provides means for rotating the same, and through it the knife-carrying arm may be swung in a vertical plane to vary the vertical angle of presentation of the cutter to the tunnel breast.

The cutter-carrying arm is provided at its rear end with oppositely-directed trunnions *E*, which are mounted in suitable bearing blocks fitted in sockets formed in the upper ends of the standards *C*. The bearing blocks are secured in the sockets by screw-bolts fitting into screw-threaded hollow bosses on the blocks and the bottoms of the sockets respectively.

The rotary cutter *B* consists of a number of U-shaped cutting blades *F*, which are attached at their ends to laterally-separated bars *K*, which in turn are secured to a central hub that is fixed to a shaft rotatably mounted in the bearing members *G* of the cutter-carrying arms. The looped or closed portions of the blades are sharpened to constitute the cutting edges; and the side members or legs of the knife blades are removably secured to the bars *K*. The side bars of the cutting wheel are braced and reinforced by intermediate webs in a suitable manner. One end of the shaft carrying the blade hub extends beyond its bearing member, and carries a worm wheel *H* that meshes with a worm screw *I*, which is rotated by a suitable motor through the medium of the shaft *J*.

The cutter is best operated by means of an electric motor, which rotates the shaft *J*, and is properly mounted on a supporting shelf *L*, that is carried by the rear end of the cutter-carrying arm below the pivot trunnions, and which extends between the dependent portions of the lateral members of the arm. As the motor is carried by the arm, the relation of the motor to the worm wheel is maintained without variation in all angular positions of the arm. The current may be carried to the motor by means of flexible wires drawn along with the carriage as the machine advances with the excavation. A suitable stopping and

starting clutch is associated with the shaft *G*, for controlling the rotation of the cutter while the motor is in motion.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

RECENT DEVELOPMENTS IN WOOD BLOCK PAVING.*

By F. A. KUMMER.

SOME problems have complicated the question of wood block pavement in recent years to such an extent that unless these problems could be solved, the use of this type of pavement could hardly be very extensive. These problems were partly of a commercial and partly of a technical nature. They involved, first, the increasing price and the decreasing quality of the long-leaf yellow pine, which has been considered the most adaptable wood for such purposes, available for the manufacture of paving blocks; second, the enormous increase, amounting to several hundred per cent, in the cost of rosin. These are both commercial questions, but they brought in their train a very large number of technical questions, the solution of which has not been easy. Ten years ago the average manufacturer of long-leaf yellow pine in the South would use every effort to obtain an order for one or two million feet, or more, of all heart long-leaf yellow pine, cut from the best part of the tree and of a very superior quality. To-day there is not a lumber manufacturer in the United States who would accept such an order, and only at very high prices can lumber of good quality be secured. It is a well-known fact, for instance, that the density of yellow pine between the lower and upper parts of the tree varies as much as 30 per cent, and yet to-day the lower and larger parts of the tree are being used for large-sized timbers, while the smaller and less dense parts are being cut up into paving block or material of a similar small dimension. Then, too, the exclusion of sap wood in the lumber has become and is daily becoming more and more difficult. These conditions would result either in the production of a paving block so costly that it could only be used on the most heavily traveled and luxurious streets, or in the production of a block which would be inferior in quality. Neither of these results was in any way desirable, and it therefore seemed evident that manufacturers of paving block must find a substitute for long leaf yellow pine to avoid these conditions. The United States government has also taken a very lively interest in this question and through their suggestions, as well as through those from other sources, it was concluded that one of the gum woods, existing largely in the South and known as black gum, possessed all the requirements for successful use as a paving material. This wood, on account of the difficulty in preventing it from warping, and other inherent qualities, has been used very slightly for general purposes. It resembles the Australian hardwoods that were formerly used abroad for wood block pavements, but while very dense in grain and tough, is not so hard as those woods and not so proof against decay. It was felt, however, that properly treated, it would make a block, if anything, superior to Georgia pine, and actual tests in service indicate this to be the case. Blocks of this character have been laid for somewhat under a year on Hudson Street, New York city, between the tracks of the Metropolitan Street Railway Company and extending from Dominick to Watts streets. These blocks are standing up under heavy travel better, if anything, than pine adjoining them in the same location. This wood possesses the great advantage of running uniform throughout and is unlike yellow pine in that it does not have the great distinction and difference in durability between sap and hardwood. It will prove a most desirable and valuable addition to the timbers available for paving block purposes.

Returning to the question of the treatment, the advance in the price of rosin from $1.40 to $4.70 per barrel naturally suggested the use of another material, if another could be found equally as good, or a reduction in the amount used, provided this reduction could be made without decreasing the quality of the product. Great difficulty has been found in obtaining any material which will take the place of rosin as a material for waterproofing and hardening the blocks. Asphalts and pitches will not mix with creosote oil, so that their use is in this way prevented, nor have they the advantage of hardening the fiber of the wood. A thorough investigation of the subject led to the conclusion that the only way in which the amount of rosin used could be reduced would be by improving the quality of the oil. Creosote oil is generally tested for its specific gravity and also for its volatilizing points. By increasing the specific gravity of the oil called for and greatly reducing the amounts that evaporate at given temperatures, a far heavier, denser and more permanent oil may be secured, and with the use of such an oil, the amount of rosin may be safely cut in half. These statements are not made off-hand, but are the result of long and continued experimentation, both as to the possibility of securing thorough treatment with oils of this character, and also chiefly, as to the waterproof qualities of the resulting product, and it has been found that blocks treated with oils of this character containing only 20 to 25 per cent of rosin, are, if anything, more waterproof than blocks treated with the lighter creosote oils with 50 per cent of rosin.

These results led to the very gratifying conclusion that manufacturers of wood block can produce a pavement inferior in no respect to those which have been laid in the past, and, if anything, in some respects superior, and which they can safely guarantee under the heaviest travel, without being obliged to ask for such block prices so high as to become prohibitive.

In speaking of these questions, I have not made any reference to the method of treating paving blocks. If this is not well known to all of you, it is sufficient to say that blocks, after being cut to size, are placed in circular cages made of band steel of approximately the diameter of the cylinders in which the treatment takes place, and are then while in these cages run into the cylinder on cars. The cylinders themselves are usually about 6 feet in diameter and somewhat over 100 feet long, and are provided with steam coils along the bottom and sides to provide heat for drying and preparing the lumber for treatment. The blocks are heated in this way, some works employing live steam instead of steam coils and others a combination of the two. After several hours, both by the use of heat and by the use of a vacuum pump, a large portion of the moisture and light volatile oil in the wood, if the latter contain any such, are driven off. The preservative material is run into the cylinder under a vacuum and hydraulic pressure of 200 pounds per square inch, applied from two to three hours, or for such longer period of time as may be necessary to thoroughly treat the charge, the result being accomplished when the gages show that no more material is entering the wood.

The question of the proper joints to use between wood paving block is one which has received a great deal of attention. Like many cases of a similar nature, it is impossible to generalize and say that any one form of joint is the best for all conditions. On streets where the travel is heavy, the blocks are laid close

* Abstract of a paper read before the Municipal Engineers of the City of New York.

together and the action of travel tends to expand the head of the block slightly, resulting in the closing up of the joints so that the surface of the street is almost as homogeneous as the surface of an asphalt street, and no crevices for the entrance of water exist. No wood block pavements will be affected by the water which runs over their surface, both because this water quickly flows to the gutter if the street is properly graded and because the surface of the blocks under travel becomes so dense and hard that they will not absorb water. Where water, however, can run under the block through the joints and remain for many days in the process of being soaked up by the pavement, expansion sometimes takes place, even with the most thorough treatment, this expansion resulting more from the character of the wood than from the character of the treatment itself. It has, therefore, been found that on streets of light travel, where the traffic is not sufficiently heavy to cause this unification of the surface, either some form of waterproof joint or else expansion joints, to take up any possible expansion of the block, should be provided. In the borough of Queens, last year, some 50,000 square yards of block were laid on streets of very moderate travel in this way. Half-inch expansion joints were left along the curb and along the rail on streets with car tracks. These joints were filled with paving pitch. Similar joints were placed across the street at intervals of 100 feet. It is very gratifying to note that not only has there been no evidence whatever of any swelling on these streets, but it does not appear that the expansion joint has been brought into play, as there is no evidence of its squeezing out as would have been the case if the block expanded. This would seem to indicate that its use in this instance was unnecessary, but it is a precaution which it is wise to take on streets of moderate or light travel.

In some of the Western cities expansion of the pavement, especially where blocks of light treatment are used, is prevented by grouting the whole surface with a paving pitch joint. This absolutely prevents the entrance of moisture into the pavement, but is open to a defect so serious that its use in this way is very limited. In spreading melted and hot paving pitch over the surface of a street and brushing it into the joints with squeeges, a certain amount is left on the surface, and under the action of the hot sun this becomes very sticky and disagreeable. In the nature of things it would be used generally on residence streets, as these streets usually have moderate travel. If used on these streets the results would be very unsatisfactory to the property owners, because as soon as the pitch gets sticky, it is traced on the sidewalks and into stores and dwellings. In the city of Baltimore some contracts have just been let in which an attempt will be made to pour the joints with paving pitch instead of spreading the pitch over the surface, but unless the blocks are separated so that the spout of the can from which the pitch is poured can run along the groove, very few, if any, workmen can accurately pour joints of this character without getting more pitch on the surface than they do into the joints.

If the pitch is spread over the surface in very hot weather, and the greatest care is taken, not only to leave as little as possible on the surface when sweeping it into the joints, but also to put sand over the surface of the street while the pitch is hot, this surface pitch will be ground off by the action of travel within a reasonably short time. But even during that period the complaints from its use will be very numerous. Still another consideration arises in the case of these joints which may not be apparent at first thought. On prominent business streets in large cities, if the joints are to be made with sand, it is not practical to leave a coating of sand on the street long enough for it to work into the joints by the action of travel. This results from the fact that this sand is constantly being blown into the faces of pedestrians and into stores and office buildings, to the great dissatisfaction of the public. A cement joint, inasmuch as it is run between the blocks in the usual manner, is very quickly applied, and the surface of the street may be swept clean of the sand top dressing within a short time. In fact, under these circumstances there seems very little necessity of using much, if any, sand top dressing at all, except for the purpose of filling up those few joints which the grout has not thoroughly filled.

In the beginning of the wood block industry in the East, blocks of uniform lengths of 8 inches were called for and have been called for for the past five or six years. The Western practice, on the contrary, has in many instances admitted blocks running in lengths from 6 to 10 or even 12 inches. I am inclined to believe that this provision is a very wise one, inasmuch as the length of the block has no direct relation to its wearing qualities, and it is possible to more readily obtain a lumber supply with planks ranging, say, from 6 to 10 inches in width, than by being obliged to buy all planks of one width. As far as the depth of the block is concerned, it is thought that blocks 3½ inches in depth, of proper material, and properly treated, will be quite as serviceable as 4-inch blocks, as the rate of wear is very small, and either would probably become unserviceable after one or two inches of the surface had worn off, but this amount of wear would not occur in a very long period of time. For decreasing the cost of the pavement on less important streets, 3-inch blocks have been very successfully used; but there are mechanical objections to using blocks of less depth than 3 inches, as they have not sufficient depth to bind them properly in the street.

It has been thought by many people in the past that the constant sprinkling of wood block streets is to their advantage. It has been my observation that such sprinkling is a very great disadvantage and greatly reduces the resistance of wood block pavements to wear, the reason for which is considered very evident. If the surface of the street is kept constantly wet and then pounded by heavy travel, the upper fibers of the wood are softened in just the same way that any other material, even stone, is more easily worn away when wet than when dry. Tests made by the United States government, Bureau of Forestry, on the relative resistance of wood to breaking, crushing, etc., when wet and dry, show differences extending in some cases up to 100 per cent, and the presence of moisture in the fibers of wood block will cause it to wear out much more rapidly than if kept dry. Warren Street, New York, the first street laid in Manhattan with wood block, with the exception of Twentieth Street, originally laid some ten years ago with Australian hardwood, was for a long period after it was laid kept continually wet under a private sprinkling contract. Last year this sprinkling was stopped. I made a careful examination of blocks taken from this street and found in many cases the tops of the blocks, instead of being pounded down and dense and hard, as is the case on streets not so sprinkled, had broomed out under the action of travel, and the preservative material mechanically pounded out of the wood by the combined action of the travel and the water. This, of course, leaves the surface of the block unprotected by the antiseptic preservative and ready to decay. It also, in its spongy condition, offers poor resistance to wear. For this reason it would seem very desirable that wood block streets should be sprinkled only so much as is necessary to sweep their surface properly, and should be kept clean and free from dust rather than to depend upon the old-fashioned plan of converting the dust into mud by putting water on it. There is no difficulty in keeping wood block streets clean, because unlike asphalt streets the wear upon them does not produce a fine dust, and unlike granite block streets, there are no large joints or crevices to hold dirt.

The mortar bed as a substitute for the sand cushion, used abroad extensively, and first suggested in New York city by Mr. George W. Tillson, chief engineer of the bureau of highways of the Borough of Brooklyn, has proved in every way a decided advance over the sand cushion. It will not hold moisture to any appreciable extent and it cannot shift, and always maintains the block in a rigid position. Wood block, being in itself elastic, requires no cushion, as would be the case with stone or brick, but while wood block pavements have a very long life if the individual blocks which compose the street are kept perfectly to grade, it is one of the most easily destroyed pavements in the world if the surface becomes uneven, and this can never be entirely prevented where a sand cushion is used.

[Concluded from SUPPLEMENT No. 1601, page 25658.]

FUNDAMENTAL PRINCIPLES OF GAS ENGINES AND GAS PRODUCERS.*

By ROBERT T. LOZIER.

GAS.

THE chemistry involved in gas engineering as far as the first principles are concerned is very simple. There are three elements to be considered in the gas mixture. First, the combustibles; second, the supporter of combustion; third, the inert matter. All of the gases that are used in gas engines are composed of identically the same elements only in each case they are composed of different proportions. These elements are as follows: The combustibles are carbon and hydrogen and their combinations; the supporter of combustion is oxygen, the inert element is nitrogen. The gas supplies the carbon and the hydrogen. The air supplies the oxygen and the nitrogen. Now when the gas bearing the combustibles from the coal is mixed with the air and ignited, the heat which takes place as the result of their burning expands the nitrogen in the air, and the carbon dioxide; the latter results from the burning of the carbon and the oxygen. We might also include the expansion resulting from the watery vapor which is the product of combustion of the hydrogen; and the aggregate results of this expansion cause the power in the engine. If a gas is rich in combustibles, such as natural gas, we admit a large percentage of air into the mixture so as to supply enough oxygen to obtain complete combustion. If the gas is lean, such as producer gas, we admit less air and more gas, because the gas does not demand so much oxygen for a given volume in order to obtain complete combustion. After the piston has been forced out on its work stroke, the inertia returns it on its back stroke, and pushes out into the exhaust the nitrogen and the products of combustion which are CO_2 (carbon dioxide or carbonic acid gas) and H_2O (water). These products of combustion are obtained in this way:

1. All carbon burns completely to CO_2 } after
2. All hydrogen burns completely to H_2O } explosion.

I am referring to such gases as are most largely used in this country, viz., Natural Gas, Illuminating Gas, Coke Oven Gas, Producer Gas, and Blast Furnace Gas. There are several other gases used in gas engines, such as Mond Gas, Dowson Gas, and lately Acetylene Gas, but they can hardly be said to have a large commercial use in this country.

The accompanying tables will give the various characteristics of these gases.

The selection of any given gas for use in an engine is largely determined by its accessibility and cost. One thing that has stood in the way of adopting large gas engines in this country has been the inability to obtain a cheap power gas where natural gas, coke oven gas, or blast-furnace gas has not been available. Since, however, the advent of the successful producer that can handle hard coal, soft coal, lignite, wood, coke, or charcoal, and gasify them with that perfection that the engine demands, the enterprise of the American engineer has led him to push rapidly to the front and successfully build large gas engines, that not only contain the best elements of the gas engines so largely developed in England, France, and Germany, but are now up to the very highest standard of steam engine construction and operation. While undoubtedly England because of its well-developed producers, Germany because of its high-priced, low-grade coal on one hand, and available blast furnaces on the other, have in the past gone far ahead of us in the development of the gas engine, since the appearance of the successfully developed producers Americans are now forging ahead, and may be said to lead in many respects our foreign cousins in the developments made and the results obtained. Let us next, therefore, see what the gas producer looks like, and upon what principles it depends for its operation.

TYPICAL ANALYSIS OF COMMERCIAL GASES.
VOLUME PER CUBIC FOOT.
(LUCKE.)

NAME.	Hydrogen H	Marsh Gas CH_4	Olefiant Gas C_2H_4	Carbon Monoxide CO	Oxygen O	Carbon Dioxide CO_2	Nitrogen N
NATURAL GAS	1.84	93.35	0.35	0.41	0.30	....	3.41
ILL'G. GAS COAL	30.78	45.16	6.38	7.04	0.6	1.08	0.50
COKE OVEN GAS	53.0	35.0	2.0	6.0	....	...	6.0
PRODUCER GAS (LITTLE STEAM)	9.2	3.1	0.8	25.3	...	3.04	58.2
LOOMIS PETTI-BONE COAL	14.0	2.0	0.30	20.0	0.10	8.2	55.5
LOOMIS-PETTI-BONE WOOD	14.0	2.0	0.30	20.0	0.10	16.0	47.7
BLAST FURNACE GAS	3.0	....	....	27.5	....	10.0	59.4

TABLE A.

HEAT VALUES OF COMMERCIAL GASES.

NAME	B. T. U. per Cubic Foot (Low)	Cubic Feet per H. P. Hour	Fuel Burned to Produce 1000 Cu. Feet	Mixture Air to Gas
NATURAL GAS	882	12	....	8 to 1
ILLUMINATING GAS COAL	762	15	60 lbs.	6 to 1
COKE OVEN GAS	646	18	.....	5 to 1
PRODUCER GAS COAL	120	80	12 lbs.	1 to 1
LOOMIS-PETTI-BONE COAL	120	80	12 lbs.	1 to 1
LOOMIS-PETTI-BONE WOOD	120	80	30 lbs.	1 to 1
BLAST FURNACE GAS	100	100	.....	1 to 1¼

TABLE B.

GAS.

CHARACTERISTICS OF COMPONENT PARTS.

Symbol	Name	Nature	As Concerns Action in Engine
H	Hydrogen	Burns with a thin snappy flame	Must be used at low compression because it ignites at low temperature.
CO_2	Carbon Dioxide (Carbonic Acid Gas)	Inert (Burnt Carbon)	Expansion by heat
CO	Carbon Monoxide	Burns with a blue flame; not luminous	Largely depended upon in the leaner gases to provide fuel.
CH_4	Marsh Gas (Methane)	Slightly luminous	A most excellent gas for gas engines; rich in B. T. U.'s; can be run fairly high in compression
C_2H_4	Olefiant (Ethylene)	Luminous	Higher series than Marsh gas; more illuminants; higher in B. T. U.'s
O	Oxygen	Sole supporter of combustion	Enables Gas to burn
N	Nitrogen	Inert	Expansion by heat

TABLE C.

HEAT VALUES OF COMPONENT PARTS.
(LUCKE)

NAME	Heat by Combustion (Low) Per Cubic Foot	Heat by Combustion (Low) Per Lb.	Mixture of Air to Gas Required
H Hydrogen	278.7	51804	2.4 to 1
CH_4 Marsh Gas	932.3	21502	9.6 to 1
C_2H_4 Olefiant Gas	1513.5	19834	14.4 to 1
CO Carbon Monoxide	329.6	4395	2.4 to 1

TABLE D.

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* Paper read before the New York Electrical Society and published in its Transactions.

PRODUCERS.

The plant is most simple and consists essentially of a generator and a scrubber. Auxiliary apparatus in some cases are used, such as economizers, tar extractors, exhausters, and gas holders.

The generator consists of a large sheet-iron shell higher than it is round, and lined with firebrick, provided with an opening at the top, through which the fuel is supplied, and a grate at the bottom for taking out the ashes. Also inlets for air and steam, and outlets for gas. They are generally designed with one square foot of grate surface, per 12 to 20 pounds of coal, and burn at an average temperature of about 1,900 deg. F. They have a thermal efficiency of something over 80 per cent, and will gasify 1 pound of coal into about 85 feet of producer gas. There are two general classes of producers, which may be called updraft and downdraft producers. The updraft is divided into suction producers and pressure producers. Describing the updraft first. Air mixed with saturated steam is drawn up through the incandescent fuel in insufficient quantities to prevent complete combustion, but in sufficient quantities to cause such a combustion that will release the carbon of the coal and allow it to enter into chemical combination with the oxygen of the air, forming carbon dioxide (CO_2). This carbon dioxide continuing up through the incandescent coal takes up more carbon and is changed into carbon monoxide. $C + CO_2 + Heat = 2\,CO$. When water in the form of steam is mixed with the air blast, and comes in contact with the burning fuel, the hydrogen is liberated, and the oxygen unites and forms more carbon monoxide $C + H_2O + Heat = H_2 + CO$. To these products must be added the volatile matter that is distilled off the top of the fuel bed, which consists for the most part of marsh gas (CH_4) and hydrogen; the other main constituent of the gas is the nitrogen of the air, which passes through the fire unscathed like our old biblical friends Shadrach, Meshach, and Abednego.

These elements compose a gas which we call "Producer Gas." This gas then enters the bottom of the wet scrubber through a water seal, which prevents it backing into the producer, and passes up through its trays containing coke or coal over which water is continuously dripping, and which washes or scrubs the soot, dust, and possibly sulphur out of the gas. From the wet scrubber the gas passes through a dry scrubber, which takes out some of the moisture and further cleans the gas. This dry scrubber is filled with excelsior. The gas is then ready to put in the holder, or to be used in the engine direct.

If bituminous coal is used with an updraft producer, the volatiles pass off the top of the fire and mix with the gas in the form of a vapor, which condenses into tar. This tar must be extracted, or otherwise the engine cannot operate. The method used to extract the tar is generally to pass the gas through a rotary device in which blades rapidly revolve through water in which the gas is passing. The water condenses the tar, and the blades beat it out. It is to be pointed out that this tar contains some of the richest elements in the coal, and varies from 18,000 to 20,000 B. T. U. per pound, which would be lost to the fuel account. Other auxiliary devices for pressure plants are a small boiler, the steam from which under pressure enters with the air, with sufficient force to make a draft through the producer, and to force the resulting gas into the holder. Some systems use an exhauster, which draws the air through the producers, and puts the gas into the holder, and, of course, with such plants are furnished the holders.

The importance of not only entirely eliminating the tar but doing so in a way to save its high calorific value led Messrs. Loomis and Pettibone to design their down-draft system. The air taken down through the opening at the top of the producer carries through the deep incandescent fuel beds the volatiles liberated from the unburnt coal fed to the top of the fire. This action breaks up the volatiles into fixed gases of high calorific value, so that from 5 to 10 per cent of the total B. T. U.'s in a bituminous coal are saved, which would be lost if the volatiles condensed in the tar were extracted.

It is, of course, necessary to introduce steam through these fires for two purposes, first, to cool the producer fire; second, to disintegrate the ash. The cooling of the fire is accomplished by carrying off in the form of latent heat that necessary to break up the H_2O of the steam into the hydrogen and oxygen. Disintegrating the ash is accomplished, first, because the fires are not allowed to reach a temperature high enough to make the clinker flux, due to the melting of the sulphur. Second, it is assumed that the steam forms envelopes around the particles of ash, and prevents large clinker from forming. It has been suggested by some that sulphureted hydrogen is formed, and that this in some way helps to break up the clinker. So that when it is found that all the coal has become thoroughly incandescent, the air supply is shut off, the steam is then circulated through the generators for a few seconds, as just explained, and in this manner the producer fires are kept in the right condition, without any poking whatever. The steam, which comes from a waste heat boiler through which the hot gases from the producer pass, is turned into water gas, which can be used to enrich the producer gas, or if desired, can be led into a separate holder, and used for various industrial purposes, such as annealing, and tempering furnaces, enameling, singeing, etc. It will be seen from one of the pictures that this Loomis-Pettibone system is also available to gasify wood, lignite, and other low-grade fuels. Lignite is most successfully gasified by this process, and produces a lean gas, well adapted to gas engine operation at a satisfactory consumption of lignite.

CHEMICAL AFFINITY AND ITS POSSIBLE CAUSES.

By GEORGE E. BOLLES, Ph.G., D.D.S.

BEFORE offering the contents of my paper, I would like to make a few remarks of explanation. This is, I believe, necessary, firstly, because the facts to be stated are of no practical value to practical pharmacists, and secondly, because by furnishing or supplying a nucleus around which to fasten the attention, the reader will be the better prepared to receive and appreciate the statements that are to follow.

The title of this paper is "Chemical Affinity and Its Possible Causes."

Chemical affinity or chemism is a force of a very peculiar and mysterious nature, existing everywhere and manifesting itself at every instant. By the operation of this force plants are permitted to build up starch, as food for future use; and in turn also to build up for themselves living tissue or cellulose. It also facilitates the removal of poisonous and waste products from the animal organism, and furthermore it permits us to operate in a great field of synthetic chemistry and in this way build up an almost infinite number of complex substances valuable as therapeutic agents.

Now, the question before us is, what are the necessary molecular or atomic conditions of elements in order that they may unite chemically with each other? It is true that the gaseous state, as well as that of fusion and solution, facilitate chemical union, but surely such petty considerations will not suffice in our present stage of progress and intelligence.

It is the molecules, atoms, or more probably the electrons, which concern us, and to which I now ask you to direct your attention.

CHEMISM AS A MOLECULAR FORCE.

What is chemistry? The general attempt to supply a definition, suitable in all cases, for this important branch of study has been to a great degree unsuccessful. In most cases the writer appears to be so conspicuously enthusiastic in his or her desire to become thoroughly explicit in the matter, that it is only by numerous complicated statements that such an object is accomplished. Consequently definitions involving such complications, which must certainly result, with an object of that nature in view, are far from being within the immediate conception of the reader.

A definition, however, which is within the conception of all, as well as being reasonably comprehensible and sufficiently exhaustive, is the following:

Chemistry is the study of *force* by which *matter* becomes *permanently* altered in properties.

It will be noticed that special emphasis is applied to the words force, matter, and permanently.

The word permanently in our definition tends to invite, to our understanding, a very simple method of discriminating between definitions of physical and chemical changes.

Those three words really form the quintessence of the definition, and should therefore be carefully considered.

Matter can be defined as anything that occupies space and exhibits gravitative attraction.

Matter may be conceived of in three physical states, namely, liquid, solid, and gaseous.

All of the matter of which our earth and atmosphere are composed can be resolved, in a few cases with some degree of difficulty, into what are generally termed simple substances.

These are so termed, because they cannot by any known method be resolved into any simple form of matter.

Such simple substances are called elements, owing to their elementary character.

A body is a collection of material particles. Elements being collections of material particles are classed as bodies.

Bodies are made up of small particles called molecules and these molecules are made up of still smaller particles called atoms.

Atoms of elements cannot exist by themselves, but they unite with similar atoms and form molecules.

Atoms are not capable of being conceived of, they are so minute, and they are only capable of existing in combination with some other different atom or atoms.

The force which causes the union of heterogeneous atoms is very little understood, but for the convenience of utterance this very peculiar force is called chemical affinity or chemism.

It is this most subtle power or force which has within itself the ability to conceal from us for a time the two gases of which water is composed.

Is there anything in the common properties of water to indicate that it is a compound of two elements and both of them gases?

It has also the ability to make almost an infinite number of similar concealments, and some of them more wonderful than the one just mentioned.

Chemical affinity or chemism manifests itself with different degrees of intensity, which may be expressed as very mild, mild or violent.

Why should this chemism appear so partial in some instances?

Why should not the different elements unite with one another with like degree of intensity?

It seems only reasonable to suppose that this affinity is a manifestation of a force, very similar and perhaps identical with the one which manifests affinity between the notes of the musical scale.

This theory then is a vibratory one, and chemical harmony established according to the degree of similarity of the rapidity, direction, and amplitude of the vibrations of the molecules, that is manifested, in the combining elements.

Just as there are musical discords, so are there also chemical discords.

Discords may be considered as partial or complete, or otherwise expressed as harmony, absent, partial or complete.

Two molecules of different elements coming in close proximity to one another, and under favorable conditions, will in a great many instances manifest affinity for each other, and as stated before, it may be manifested in a very mild, mild or violent degree, and possibly the degree of combining power governed and regulated according to the degree of similarity of the rapidity, direction and amplitude of the vibrations of the molecules in the combining elements.

Now, considering the matter very carefully, it appears reasonable to state that, when two molecules of different elements are brought together, and do not manifest affinity for each other in any marked degree, it is due to the fact that chemical harmony is not complete but only partial.

Of course when chemical harmony is only partial, there is some degree of affinity manifested, which is quite sufficient indication that there are certain points of similarity in the vibrations of the molecules in the combining bodies. This similarity may be in the rapidity of the vibrations of the molecules, or such similarity may be entirely confined to the direction or to the amplitude of the vibrations.

When such similarity exists, as above stated (that is, any one of them), then the intensity with which the factors unite chemically may be very mild.

If, however, this molecular similarity be not entirely confined to the direction, rapidity, and amplitude of the vibrations (that is to say, any one of them) then the similarity may be extended over two of these characteristics, namely, rapidity and direction. Two combining elements having two vibratory characteristics will manifest greater affinity for each other than two combining elements having only one similar characteristic.

Consequently, when two combining elements are to unite chemically together, under favorable conditions and having two similar characteristics, they will do so with an intensity which we express as mild. To recapitulate, it is well to state that when two different elements are brought together under favorable conditions, and having only one similar vibratory characteristic (which similarity may be in the direction, rapidity or amplitude of the vibrations of the molecules), they are said to manifest affinity for one another with an intensity expressed as very mild.

But as before stated, this one vibratory characteristic is not necessarily confined to the rapidity nor to the direction of the vibrations, but may be any one of the three.

When, however, two elements are to unite under favorable conditions, and having not only one vibratory characteristic, but two of such characteristics, then their affinity for each other is conspicuously augmented, and the degree of affinity manifested expressed as mild. From our suppositions, it does not follow that two vibratory characteristics must necessarily be any particular two, but to any two of the whole three, namely, rapidity and direction, direction and amplitude, or rapidity and amplitude.

Any two combining elements, besides possessing one or two vibratory characteristics, may possess as many as three of these characteristics, namely, rapidity, direction, and amplitude.

When vibratory similarity becomes extended over all three of such characteristics, then the degree of combining power is sufficiently intensified to be expressed as violent.

It is not to be expected that two combining elements must necessarily possess identical vibratory characteristics to manifest mutual affinity (they may be nearly identical), but which may also be in some direct ratio to each other.

It appears that chemical affinity or chemism has little or nothing to do with quantivalence, as for example, in a good many instances the higher chemical compounds are not so stable as some of the lower ones, that is, if chemical affinity has anything to do with stability.

It is noticed that in the case of hydrogen and iodine when brought together, they are quite inactive compared with the activity manifested between hydrogen and chlorine or hydrogen and bromine.

The quantivalence of these elements is the same in each instance, but the degree of combining power vastly different.

Giving the atomic weights of the elements due consideration as to the probable cause of chemical affinity or chemism would not be considered as altogether unreasonable, but justly improbable, as these are the parts by weight in which elements unite to form definite chemical compounds, but it does not explain the cause of such manifestation. Naturally it concerns us sufficiently to inquire, and so far as possible calculate, the amount of energy contributed by the sun to promote and modify chemical affinity, or chemism.

The giving birth to new theories, especially those involving such somewhat obscure considerations as those cited in this paper, becomes necessarily very complex, and this fact, it is hoped, will be earnestly appreciated by all readers, in order that they may assist in the elucidation of the subject.

REVERSING SHAFT GOVERNOR ENGINES.*

By W. H. WAKEMAN.

DIRECTIONS for reversing slide valve throttling engines, or any other kind in which an eccentric is fastened to the crankshaft, are found in many books and papers, although if some of them were strictly followed the engine would not run in the opposite direction, while others would cause them to revolve, but at a great disadvantage, so far as the use of steam is concerned.

There are many kinds of engines to which these do not apply, and it is more or less difficult to secure reliable information that will enable an engineer who is not an expert to reverse them, especially if they are of the high-speed, automatic type, with shaft governor. This article was written to supply such information in a plain and practical way.

Fig. 1 illustrates the Skinner engine with governor set to run "over" as indicated by the arrow, or in other words, the top of the flywheel travels from the cylinder. This is a left-hand engine because when viewed from a point in front of the cylinder the governor wheel is at the left-hand side. This applies to both direct-connected and belted engines.

When it is desired to run this engine in the opposite direction or "under," as shown in Fig. 2, the long-weighted arm must be taken off and turned "end for end," to use a common expression. The heavy six-leaf spring must be turned in the same way.

These two illustrations show the appearance of the governor for both directions of travel; therefore, if the engineer in charge of an engine of this kind wishes to reverse it, he can do so by placing the parts as plainly indicated, and he can do this without understanding any of the theory of the operation if he has not time enough to study this interesting part of his business.

It will be noted that the wrist pin which carries one end of the valve rod is located to the left of the crankshaft in Fig. 1 and to the right of it in Fig. 2, showing that its relation to the position of crank is changed by the reversing process. As the wheel revolves, this wrist pin describes a circle around the center of the crankshaft as seen in these illustrations. When the engine is started, this circle is comparatively large, giving the longest possible point of cut-off, and it assumes this position whenever a full load is thrown on, but for all lighter loads the circle is smaller accordingly, giving a shorter point of cut-off.

In these two illustrations I have presented outlines of the whole engine in order that the matter may be well understood, but this is not necessary in other cases; therefore, only the governor in each case will be shown.

Fig. 3 illustrates the McEwen right-hand engine governor set to run "over." The wrist pin is shown at 2, and it will be noted that there is another hole in the arm directly below it; 3 is a dash pot, and as centrifugal force interferes with its free operation at high speeds, the weight, 4, is provided to counterbalance it and prevent undue friction. The governor arm is pivoted at 5 and a rubber buffer is provided at 6 for its extreme travel in one direction, and at 7 for the opposite extreme.

Fig. 4 is the same governor set to give motion in the opposite direction. The wrist pin, 2, is now in the other hole provided for it, and all figures refer to the parts mentioned in connection with the preceding illustration.

When changing a governor to give a reverse motion, care should be taken to preserve the tension of whatever kind of spring is used. This can be done in the case of a spiral (or more properly speaking, a helical spring), by noting the distance between the coils before disturbing them, and restoring it carefully after the desired change is made.

Another point to be considered in this connection is that in this case and perhaps in others there are two ways of altering the strength of spring. One is to give the coils more or less tension, and the other is to increase or decrease the number of coils in tension by a device not shown in the cuts, but which will be readily seen on the engine.

Fig. 5 illustrates the Rites governor as used on the Watertown engine, when revolving in the direction indicated by the arrow, and Fig. 6 shows the same governor when adjusted to run in the opposite direction. As these governors are used on several high-speed engines, it is not practical to mention all of them here, but engineers in charge of any engine controlled by a Rites governor can learn how to reverse it by studying these two illustrations.

For illustration, suppose that when one of these engines is compared with the illustrations that it agrees in direction of motion and form of adjustment with Fig. 5. If the engine is to be reversed then it must be changed to agree with Fig. 6. To do this it is necessary to take off the governor arm and turn it over, then change the location of pins which serve as stops, also to change the spring pin which holds the outer end of the helical spring.

It is not practical to state which is for an engine running "over" nor for one traveling "under," but the following rule applies in such cases. An adjustment that is correct for a right-hand engine running "over" will also answer for a left-hand engine running "under."

In all engines before mentioned movement is given to the valve by means of a wrist pin revolving in a circle about the center of the crankshaft. In others the same result is secured by an eccentric that encircles the crankshaft, but is neither fitted nor fastened to it. When the load varies, the governor causes this eccentric to swing across the shaft like a pendulum, causing the center of eccentric to approach or recede from the center of shaft, as the case may be, thus giving the valve a longer or a shorter stroke, exactly as the wrist pin does on engines already mentioned.

Fig. 7 illustrates a governor of this kind as used on the Harrisburg engine when revolving as indicated by the arrow. The eccentric is pivoted at 2 and swings across the shaft, 3, as described, by action of the weights, 4 and 5, which are pivoted at 6 and 7, respectively.

The action of these weights is opposed by the two helical springs, the outer ends of which are adjusted in slots. After reversing this governor, if it does not respond quickly to changes in the load, move the ends of these springs toward the rim of wheel, but if too sensitive, move them toward the center. While these slots are not parallel to any of the spokes, they are inclined sufficient to make these directions clear.

Fig. 8 is the same governor when set to run in the opposite direction. Numbers refer to the same parts in both illustrations.

Some of the shaft governor engines cannot be reversed; therefore, if the flywheel of such an engine must run in the opposite direction for any cause, it is necessary to turn the engine around to secure the desired results. The Straight Line engine is a sample of this class. There are others that could be made reversible, but the builders have never considered it necessary to develop this feature. The Erieco engine is an illustration of this kind.

Concerning the need of information that will enable an engineer to reverse an engine, the following incident will serve as an illustration. A certain engine rated at 300 horse-power was sold to be removed. When erected in its new position, the engineer discovered that it revolved in the wrong direction, as it turned his machinery backward. He decided to cross the main belt as the only practical way to provide a remedy, but a friend advised him to reverse the engine and he engaged a more competent engineer to do it. Under some conditions an engine looks very awkward when running "under," and there are very few that really operate as well when turning in this direction, but if the main belt on one of this size should be

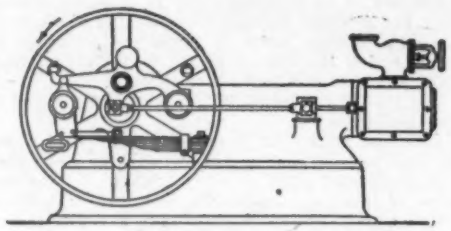

FIG. 1.—SKINNER ENGINE.

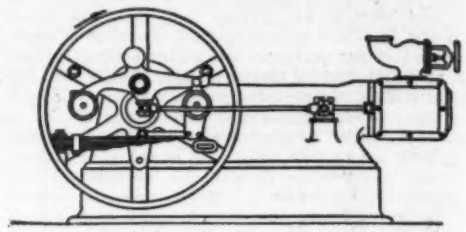

FIG. 2.—SKINNER ENGINE REVERSED.

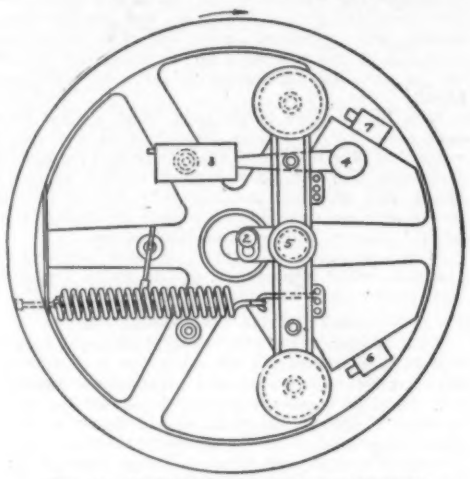

FIG. 3.—McEWEN SHAFT GOVERNOR.

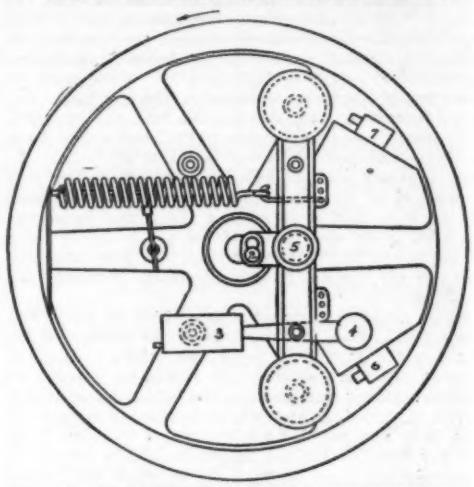

FIG. 4.—McEWEN GOVERNOR REVERSED.

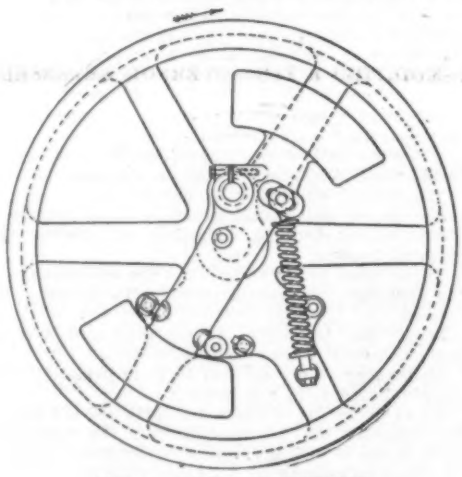

FIG. 5.—RITES GOVERNOR.

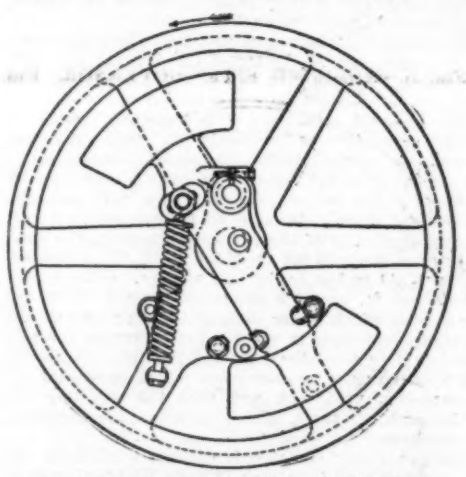

FIG. 6.—RITES GOVERNOR REVERSED.

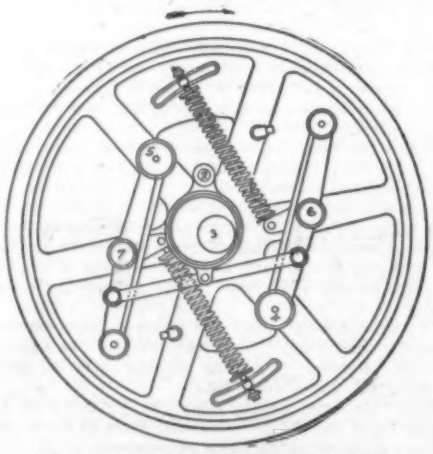

FIG. 7.—HARRISBURG GOVERNOR.

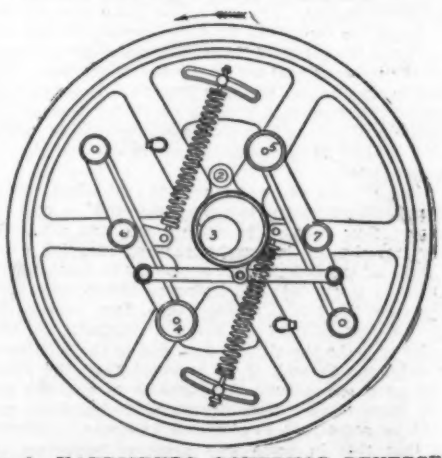

FIG. 8.—HARRISBURG GOVERNOR REVERSED.

* From the Electrical World.

crossed, much extra friction would result in wearing the belt rapidly.

Fig. 9 illustrates the Fitchburg engine governor set to run as indicated by the arrow. While this appears like a complicated piece of mechanism, it really is one of the most simple governors to reverse that is now in

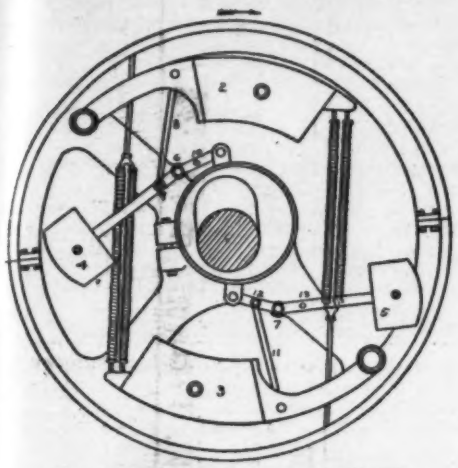

FIG. 9.—FITCHBURG GOVERNOR.

of the piston. When revolving, centrifugal force throws the weights, 2 and 3, outward against the force exerted by the helical springs. This forces the eccentric downward across the shaft (which is shown in cross section), until the opposite extreme is reached, which almost entirely cuts off the supply of steam to

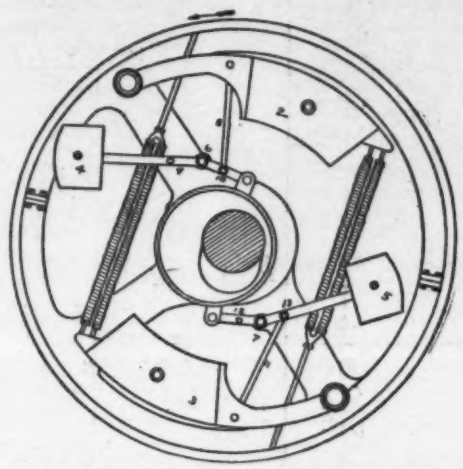

FIG. 10.—FITCHBURG GOVERNOR REVERSED.

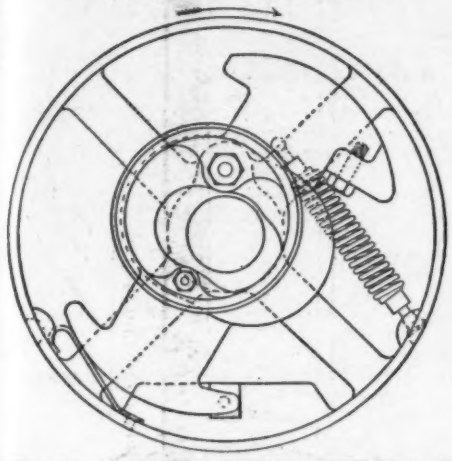

FIG. 11.—MODIFIED RITES GOVERNOR.

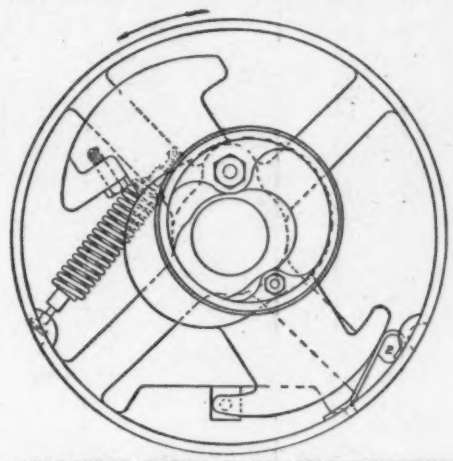

FIG. 12.—MODIFIED RITES GOVERNOR REVERSED.

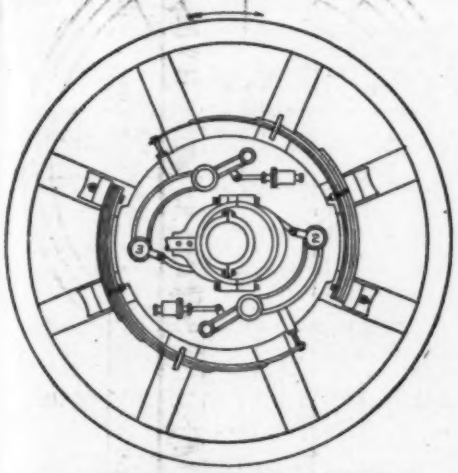

FIG. 13.—McINTOSH AND SEYMOUR GOVERNOR.

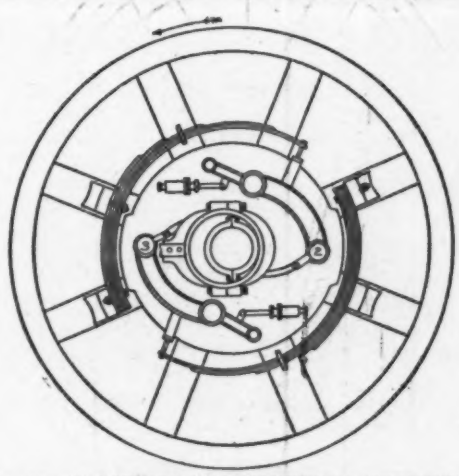

FIG. 14.—McINTOSH AND SEYMOUR GOVERNOR REVERSED.

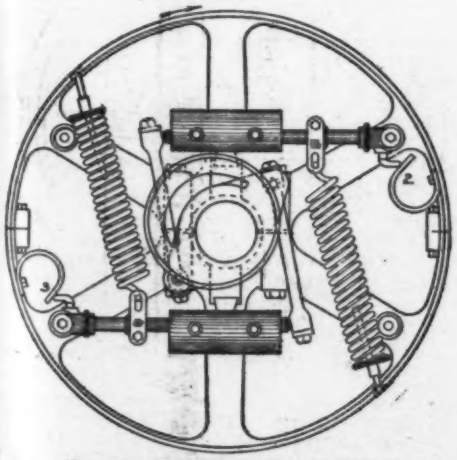

FIG. 15.—BUCKEYE GOVERNOR.

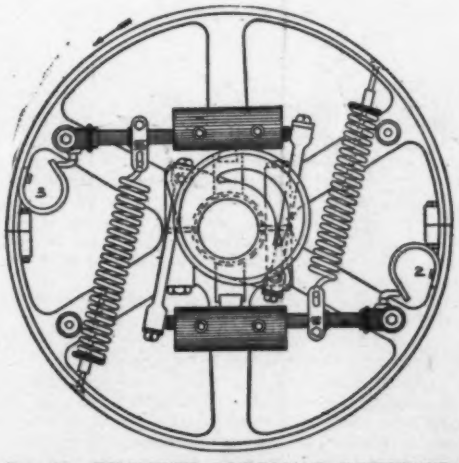

FIG. 16.—BUCKEYE GOVERNOR REVERSED.

use, except that a new eccentric must be substituted. When in the position shown, the governor is at rest, and the helical springs draw the heavy weights, 2 and 3, inward, thus raising the eccentric to its highest position, and as this gives the valve its longest possible stroke, steam is admitted for three-quarters stroke of the piston. When revolving, centrifugal force throws the weights, 2 and 3, outward against the force exerted by the helical springs. This forces the eccentric downward across the shaft (which is shown in cross section), until the opposite extreme is reached, which almost entirely cuts off the supply of steam to the cylinder. Variations in the load will give the governor intermediate position.

The auxiliary weight, 4, operates with the main weight, 2, as it is pivoted at 6, but the other auxiliary weight, 5, operates against the main weight, 3, as it is pivoted at 7, therefore 4 and 5 balance each other, but taken together they resist changes in speed; therefore, the result is a very steady speed under varying conditions.

Again referring to Fig. 9, if we disconnect the link, 8, from the pin, 9, and connect it at 10 as the weights are thrown outward by centrifugal force, it throws the eccentric in the opposite direction, as it is pivoted at 6. By disconnecting the link, 11, from 12 and connecting it at 13 it also reverses motion, because it is pivoted at 7, and we then have the governor shown in Fig. 10 ready to operate as indicated by the arrow. It is necessary, however, to substitute another eccentric with a different offset.

Fig. 11 is a modification of the Rites governor shown in Fig. 5, both revolving in the same direction, but it carries an eccentric instead of a wrist pin. The latter is used on engine with the governor near the end of crankshaft, and is called an outside connection. The former must be used on engines with the governor between the wheel and the bearing, called an inside connection, but it can also be used on outside-connected engines. An eccentric affords more wearing surface, but it travels fast accordingly, creating more friction, and requiring more lubricant to keep it cool. A wrist pin contains less wearing surface, but with first-class lubrication it proves durable because the speed of its surface is much less.

Fig. 12 is the same governor set to revolve in the opposite direction from Fig. 11, or the same as Fig. 6. A buffer spring is shown at 2, which tends to hold the governor steady under sudden changes of load. It is used on the Brownell engine.

The action of governors heretofore shown gives the valve a long stroke for a heavy load and shortens it when a part or all of the load is removed, but following illustrations show governors that give the valve a constant stroke under all changes. The cut-off is performed by rolling the eccentric forward or backward, as the case may be, to meet changes in load. Of course the eccentric must be a sliding fit on the shaft for this purpose.

Fig. 13 represents the McIntosh and Seymour governor which belongs to this class. Centrifugal force throws the weights, 2 and 3, outward, thus drawing the eccentric forward or in the direction of motion, and this regulates the amount of steam taken at every stroke. This action is resisted by the two heavy leaf springs shown.

Fig. 14 is the same governor set to revolve in the opposite direction. Centrifugal force tends to adjust the position of the eccentric to the load as before, giving very good regulation.

Fig. 15 shows the Buckeye governor, which is claimed to be the pioneer in this line. In this position the two weights are drawn inward as far as possible by the stout helical springs, forcing the eccentric backward on the shaft and giving a long point of cut-off. The auxiliary springs, 2 and 3, are now under full tension and assist in regulating speed, but are in contact only during the first half of the outward movement of the weights. During the latter half of this movement they are not in contact, as greater tension of the main springs, due to elongation of them, renders it unnecessary.

Fig. 16 shows the same governor set to run in the opposite direction. This is accomplished by changing all connections to opposite places, and taking care to set the auxiliary springs as above described. Fig. 17 illustrates the governor used by Clark Bros. to advance or retard the eccentric on the crankshaft. The weights, 2 and 3, are thrown outward by centrifugal force which is opposed by the helical springs. Arms carrying these weights are pivoted at 4 and 5, respectively, and the shaft is shown at 6. A peculiar feature of this governor is the pendulum weight, 7, which is pivoted at the extreme end. It is connected by a link to an arm carrying the weight, 2. As 7 stands at right angles to the crankshaft, it resists any tendency to change its speed very strongly on this account, hence it is valuable in maintaining nearly uniform speed under sudden changes of load.

Fig. 18 is the same governor revolving in the opposite direction. Of course, all connections are changed, and the pendulum weight is now on the opposite side of the governor.

When reversing this engine, or any other on which springs are used, care must be taken to give them equal tension, as otherwise more strain will be brought to bear on one side than the other, producing unsteady motion and lack of that perfect balance which denotes correct adjustment. This matter was referred to in connection with engines fitted with a wrist pin on the governor, but it needs to be emphasized when describing those fitted with an eccentric, as the greater revolving surface in contact tends to disturb the balance, thus enlarging the effect of any slightly incorrect adjustment.

Fig. 19 is the Russell engine governor for a right-hand engine to run "under" or a left-hand "over." The main eccentric is keyed to the shaft; therefore, if it is not well lubricated it cannot turn, as when held by a setscrew. The keyway is cut in the shaft, opposite to the crank, before the engine is finished in the shop, and it is also cut in the eccentric as nearly correct as possible, but it is sometimes necessary to make an offset key to reduce lead when the engine is tested.

To reverse this engine, the main eccentric must be turned, and if an offset key is used it must be reversed. The cut-off eccentric must be carried around on the shaft until it has the same relative position in advance of the crank that it had before. It is necessary to reverse the spring connections and weighted arms to accomplish this. The fulcrum pins for these

arms must go into holes at 60 degrees from their former places, bringing the whole into the position shown in Fig. 20. The eccentrics are made in halves to facilitate their removal.

In order to get the desired angle of advance for the cut-off eccentric, the case containing it must be turned on the shaft until brought to the right place. In cases where the governor is placed in the flywheel, a new keyway must be cut, as the wheel must be turned on the shaft.

As shown in these illustrations, the weights are in contact with buffers, which they leave as soon as moderate speed develops enough centrifugal force to overcome the action of the helical springs. The arms are slotted to admit of changing the position of weights if more or less centrifugal force is required.

NEW SUBSTITUTE FOR SOAP.

IN a special publication of the Algerian government, "Informations Agricoles," the department of botany has described a tree of the genus Sapindus imported into Algeria in 1845. This tree is the *Sapindus utilis*, also called the *Sapindus savonnier*.

The *Sapindus utilis* yields a fruit which, when ripe, is smooth, fleshy, of the size of a chestnut, and becoming on desiccation in the air somewhat coriaceous, gummy, and translucent. The color varies from yellowish green to brown. In the interior of the fruit is a black seed, smooth, spherical, and containing an oily kernel. This tree, multiplied by seed, has produced a certain number of varieties, the distinction of which is of great importance when cuttings are to be selected,

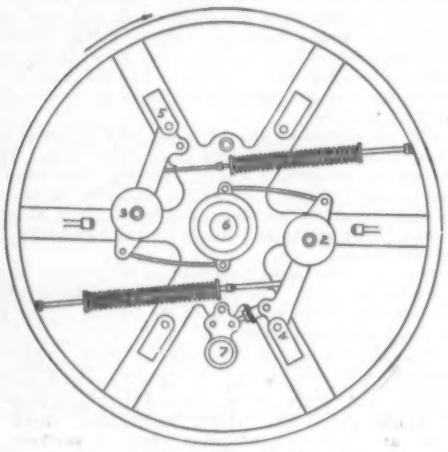

FIG. 17.—CLARK GOVERNOR.

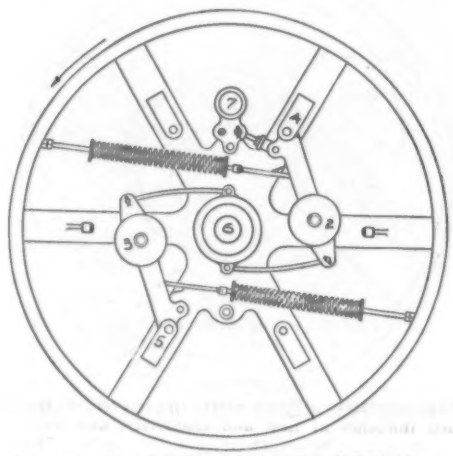

FIG. 18.—CLARK GOVERNOR REVERSED.

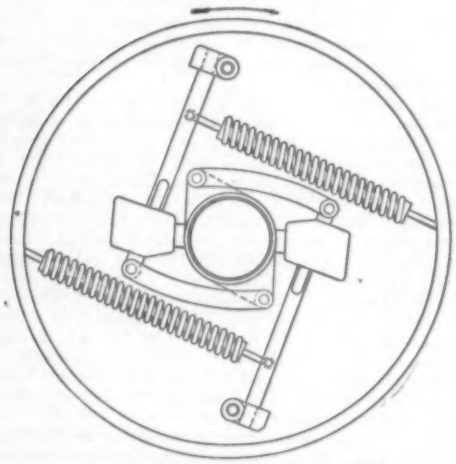

FIG. 19.—RUSSELL GOVERNOR.

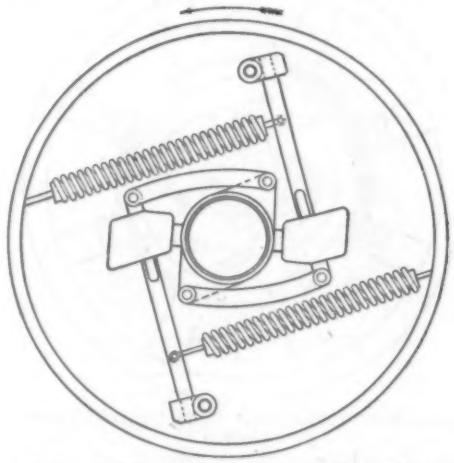

FIG. 20.—RUSSELL GOVERNOR REVERSED.

for the rudiment may vary in enormous proportions from one variety to another.

Fortunately, the Sapindus increases with great rapidity and ease. In two years a cutting, well taken care of, will attain a height of three yards. In a deep, fresh soil it may begin bearing in six years, and for many years the production increases regularly. An adult tree yields from 60 to 220 pounds of fruit, easily gathered toward the close of autumn, and even in the course of the winter.

M. Revoil, governor of Algeria, applied to me to seek for a utilization of this fruit, of which he put a sufficient quantity at my disposal. It is known that these fruits are employed as substitutes for soap in China, Japan, India, and the Antilles. They are comparable to Panama wood in the saponine contained. They also contain a gummy substance, which yields a sort of dressing for fabrics of wool and silk, washed in a decoction of these fruits.

If the fruit of the Sapindus, simply dried in the air and freed from the seed, is treated with water, a soapy solution is obtained. But a comparatively long time is necessary for the detersive action, in consequence of the gummy substance, which prevents the rapid dissolution of the saponine. If, in order to hasten the action of water, the shell is reduced to powder, success is attained with great difficulty, because the powder slips into the teeth of the grinder and clogs them. I, therefore, decided to submit the fruits, previously freed from the seed, to torrefaction. It is sufficient to expose them to a temperature of 130 to 140 deg. C. for three or four hours, to obtain after cooling a brittle substance, friable, and capable of being readily converted into a homogeneous powder. The loss of weight due to the torrefaction is about 10 per cent.

But it was important to ascertain whether the torrefaction did not cause too great a change in the composition of the fruit, principally with reference to the saponine and the gummy principle consisting of pectic substances. For this purpose I analyzed samples and obtained the following figures:

	Dried in Air.	Torrefied at 140 deg.
Water	8.94	4.02
Part soluble in water	73.92	78.89
Part insoluble in water	17.14	17.09

The torrefaction has, therefore, only a slight action on the composition of the fruit, which renders soluble a small quantity of the principles insoluble in water.

If the analysis is carried further, the following percentages are obtained:

Part Soluble in Water.

	Dried in Air.	Torrefied at 140 deg.
Water	8.94	4.02
Part insoluble in 90 deg. alcohol, cold	21.23	15.33
Calculated as saponine. Part soluble in 90 deg. alcohol, cold	52.69	63.56

Part Insoluble in Water.

Soluble in hydrochloric acid	5.12	5.53
Pectic acid	5.31	4.57
Cellulose	6.71	6.99

This analysis shows the large percentage of saponine of these fruits, even taking account of the foreign substances, which, with the method of analysis adopted, may raise the figure of the saponine a little. M. Mercier had also indicated for certain samples a percentage as high as 37.76. The bark of Panama wood contains only 8.65 per cent of saponine.

The torrefaction diminishes the percentage of the saponine, but the powder procured still contains a percentage greater than that of the fruit of the Orient, which contains 14 per cent. It may be added that the part soluble in alcohol, cold, which cannot be regarded as saponine, causes, however, abundant froth in the water with which it is shaken. It contains perhaps a principle similar to the aphrodescine discovered by Rochleder in India chestnuts, which is quite similar to saponine in its properties, but distinguished from it by its solubility in alcohol.

By torrefaction at 130 to 140 deg. C. and a simple passage through the mill, a powder is readily obtained, the constituents of which, soluble in water, are rapidly dissolved. This powder does not recover moisture sensibly when left in the air and may without modification be preserved and shipped in bags.

This powder may be readily prepared in cakes similar to cakes of soap. For this purpose it is sufficient to work up the powder with 26 or 28 per cent of water. It then assumes a red coloration, which passes to brown. At the same time the pectic compounds swell and form a veritable cement. It is easy to give to this paste a merchantable form in cakes or bars.

The addition of water should be made with much care. If the quantity is insufficient, the paste is too heavy for working. If the water is in excess, it becomes too fluid and has not the desired consistency for molding.

The desiccation of the cakes is accomplished slowly in the open air, and they acquire, after having lost about a third of the water added, perfect compactness and solidity. When afterward they are used for soaping linen, which may be done as with ordinary soap, they do not crumble, but may be entirely used up without breaking the form.

The torrefied powder put in warm water at once causes an abundant froth. In the proportion of 10 to 15 grammes per liter of water, a liquid is obtained, giving excellent results in washing, and quite comparable with the best lyes employed. Comparative experiments which have been made leave no doubt as to the result. The only precaution necessary is a more thorough rinsing to remove the yellowish color communicated to the water by the principles which have undergone the commencement of decomposition at the time of torrefaction, and to free the linen from small insoluble fragments of the powder. For avoiding the latter inconvenience it may be advantageous to stir the powder in warm water, and pour off the clear part to be employed for washing.

An important advantage of the torrefied Sapindus is that it may be employed without fear of injuring colored fabrics, since its action is produced without the addition of alkaline products. In a word, the powder formed in cakes may be employed for cleaning, just as a cake of ordinary soap is employed.

Examination of the kernel contained in the seed shows that it is quite rich in oil. But this oil is not siccative, and consequently there does not seem to be any advantage in its extraction. But the seed can be used as combustible for the torrefaction of the shells.

In fine, it is possible to utilize the shells of the *Sapindus utilis* by converting them by torrefaction and pulverization into a powder easy of transportation and employment, and capable of being prepared in the form of bars and cakes. The powder and the cakes are merchantable products which may be used directly for washing, in which they advantageously replace Panama wood. The tools necessary for accomplishing the torrefaction and pulverization may be quite primitive for a small establishment. The necessary combustible for the torrefaction may consist, for the greater part, if not for the whole, of the seeds of the fruit, of which the weight represents almost half of that of the shell, 44 per cent.

It seems, therefore, that, in addition to the factories which might advantageously procure these products on a large scale, it would be easy to create a small family industry, not requiring complicated tools, or the purchase of combustible or accessory substances, but which might be fairly remunerative, since it would utilize a product for which at present no regular employment has been found.—From the French of M. Achille Livache, engineering chemist, in the Revue de Chimie Industrielle.

CONTEMPORARY ELECTRICAL SCIENCE.*

EFFECT OF HEAT ON RADIUM EMANATION.—Curie and Danne showed that the rate of decay of radium C can be altered by subjecting it to a temperature of 630 deg. C. Bronson, on the other hand, states that heating to temperatures between 700 deg. and 1,100 deg. is without effect. M. Makower has investigated the influence of temperature on the activity of radium emanation when in radio-active equilibrium with radium A, B, and C, and when sealed up in a quartz tube so that there can have been no possibility of the escape of any volatile product. The results show clearly that the activity as measured by the β and γ rays can be changed by high temperatures, the observed effects being consistent with the explanation offered by Curie and Danne, that the rate of decay of radium C is increased by high temperatures. The experiments do not, however, prove that it is this particular product which is affected, as the results could be equally well explained if one or more of the other radio-active bodies present underwent some alteration. Further experiments will be necessary before this question can be definitely settled, but there can be no doubt that the rate of decay of one of the products is affected by temperature. The effect increases with the temperature up to 1,200 deg. C. and with the time of heating, but not after the first hour.—W. Makower, Proceedings, Royal Society, 516, March 6, 1906.

HEAVY CANAL RAYS.—To account for the large masses of canal-ray particles, E. Gehrcke supposes that they consist originally of metallic particles liberated by the disintegration of the cathode, and charged positively by the loss of electrons under the influence of ultra-violet light. They are expelled from the cathode with a negative charge, but this is soon lost and converted into a positive charge, whereupon the particles are driven back toward the cathode. The varying size of the expelled particles accounts for the magnetic "spectrum" observed by Wien. The circumstance that the particles are derived from the metal,

* Compiled by E. E. Fournier d'Albe in the Electrician

and not from the gas, explains why the material of the canal rays is able to exceed the total gaseous contents of the vacuum tube, and also why the mass of the canal-ray particle may be as much as 650 times that of the hydrogen atom. These particles are large enough to be made visible by the ultra-microscopic method devised by Siedentopf and Szigmondy. That they occur in front of the electrode was already known to Goldstein, and their slow motion there is accounted for by their having to proceed for some distance against the electric force. When proceeding with it, they must show the Doppler effect discovered by Stark. The process by which the cathode disintegrates is still obscure. It is not solely due to the electric field, since disintegration may be produced by simple heating.—E. Gehrcke, Physikalische Zeitschrift, March 15, 1906.

BATTERY FOR ELECTROSTATIC MEASUREMENTS.—F. Krüger describes a battery of small standard cells suitable for electrostatic measurements involving potentials up to 100 volts. Each cell is 5 millimeters wide and a few centimeters high. A platinum wire passes through the bottom into the cadmium amalgam, which is covered with finely-powdered cadmium sulphate. This is surmounted by wadding soaked in a saturated solution of cadmium sulphate, followed by mercurous sulphate paste and a few drops of mercury into which the second platinum wire dips. The cell is sealed with marine glue. The battery is mounted on ebonite, and is divided into five sets of 20 cells each. Its internal resistance is 0.1 megohm.—F. Krüger, Physikalische Zeitschrift, March 15, 1906.

NATURE OF OSMOTIC PRESSURE.—A. Battelli and A. Stefanini incline to Traube's view, which attributes all osmotic phenomena to differences of surface tension. They do not, however, hold that the liquid always passes from the side of lesser to the side of greater surface tension. They substitute the principle that the liquid always proceeds in such a manner that the surface tensions on both sides of the membrane are equalized. They quote experiments with water and alcohol, separated either by an animal membrane or a semi-permeable membrane of nickel ferrocyanide or porous earthenware. That liquid diffuses most quickly which, with an equal number of molecules, produces in the other the smallest change of surface tension. In the case of alcohol and water, the reduction in the surface tension of water by the addition of one molecule alcohol to N molecules of water is larger than the increase of the surface tension of alcohol by the addition one molecule of water to N of alcohol. Water, producing the smaller change per molecule, is the more active in diffusing through membranes. Solutions having the same surface tension are always in osmotic equilibrium even when they are not equimolecular, as, for instance, a 1.11 per cent solution of K_2SO_4 and a 1.78 per cent solution of $MgSO_4$. The authors conclude against the probability of osmotic pressure being purely kinetic.—Battelli and Stefanini, Physikalische Zeitschrift, March 15, 1906.

PHOSPHORESCENCE.—A. Debierne advances a theory of phosphorescence based upon thermoluminescence and the coloration of phosphorescent bodies by the radiation which excites them. Many phosphorescent bodies are colored during phosphorescence. This coloration is attributable to the formation of a new body, which persists after phosphorescence has ceased. When, however, the phosphorescent body is heated up to a certain temperature, the new body is decomposed, and gives up the energy consumed in its formation in the shape of thermoluminescence. When no coloration is produced, and there is yet a thermoluminescence, it may be assumed that the new body is colorless, or has the same color as the original body. When there is no thermoluminescence the probability is that the new substance is decomposed as fast as it is formed. This theory embraces all the facts of luminescence under a single aspect. It is well known that most phosphorescent substances are mixtures in which the real phosphorescent body is present in very minute proportions. It is this body that is sensitive to the exciting radiation. It may be transformed into several different bodies according to the exciting radiation used.—A. Debierne, Comptes Rendus, March 5, 1906.

POLARIZATION OF SECONDARY RÖNTGEN RAYS.—C. G. Barkla has succeeded in proving the polarization of secondary Röntgen rays by choosing carbon as secondary and tertiary radiator. A thick square plate of carbon was placed near an excited X-ray tube so as to be subject to a primary beam of considerable intensity. It was then the source of a secondary radiation, the total energy of which was quite a large fraction of the energy incident upon it. A beam of this secondary radiation proceeding in a direction perpendicular to that of propagation of the primary falling on the carbon was studied. In this secondary beam was placed a second plate of carbon, and the intensities of tertiary radiation proceeding in two directions at right angles and perpendicular to the direction of propagation of the secondary beam were observed by means of electroscopes placed in its path. The X-ray tube was turned round the axis of the secondary beam, while everything else was fixed, and the relative intensities of the tertiary radiations observed for different positions of the tube. It was found that the intensity of tertiary radiation reached a maximum when the directions of propagation of the primary and tertiary were parallel, and a minimum when they were at right angles, showing the secondary radiation proceeding from carbon in a direction perpendicular to that of propagation of the incident primary to be polarized. The results show that the amount of polarization was enormous in comparison with what had been found in the primary beam proceeding direct from an *X*-ray tube, and indicated almost complete polarization of the secondary beam. Such polarization cannot be traced in iron, since the electrons are there no longer mutually independent.—C. G. Barkla, Proceedings, Royal Society, 516, March 6, 1906.

ENGINEERING NOTES.

The Pennsylvania lines have made arrangements to equip a locomotive with a device for burning pulverized bituminous coal. A trial of this process in the power plant of the Chicago passenger depot of the Illinois Central Railway was very fully described in this journal some time ago. The present trial in locomotive use is primarily the result of a desire for smoke abatement in the Pittsburg district. In addition to this the railway company is appointing smoke inspectors on the various divisions of the Pennsylvania lines which enter Pittsburg.—Railway and Engineering Review.

Dr. H. C. H. Carpenter read a paper before the Engineering Section of the British Association on the structural changes which take place in nickel wire at high temperatures. The research had been carried out in order to ascertain, if possible, the reason for a fundamental change in the mechanical properties of nickel wire used as the heating-coil of an electrically-heated porcelain tube-furnace. The wire contained 98.60 per cent of nickel, 1.22 per cent iron, 0.16 per cent manganese, and a trace of cobalt. Some dissolved gas or gases were also present. The diameter of the wire was 1/16 inch. The ultimate tensile stress was 35.2 ton per square inch, with a percentage elongation of 34.4 on 3⅜ inches and a percentage reduction of area of about 70. The resistivity at 0 deg. C. was 9.2 michroms-centimeters. In building the furnace the wire was wound round an unglazed porcelain tube 1¼ inch external diameter, which was inclosed in a wider one, the intervening space being filled with crushed quartz. The ends of the furnace consisted of porcelain slabs which fitted into the wider tube, and were bored so as just to allow the passage of the narrower tube. In actual use the wire carried 20 amperes at 50 volts pressure, and a temperature of 1,200 deg. to 1,300 deg. C. could be obtained in the tube. With care the life of such a furnace was usually three or even more months. But sooner or later it broke down. The wire was then usually found to be so brittle that it could be snapped between the fingers. Occasionally it was still tough, but had become perfectly fibrous. These changes of mechanical properties were accompanied by structural changes which had been studied with the microscope. They were the result of the combined influence of heat and electricity, and were not produced by either of these agencies singly. The changes were due mainly to two effects, viz., recrystallization and the penetration of gases, which were themselves the result of heat and electricity on the metal. The frequent association of brittleness with gross crystallization had long been known. But the evolution of dissolved or combined gas or gases from nickel and their mode of penetration through and eventual exit from it by means of cracks between the gross crystals were, it was thought, described for the first time.

A recent investigation of the condition of the cable railroads in San Francisco since the earthquake and fire discloses the most disastrous results from the calamity and the necessity of abandoning this system of construction hereafter. Cables for street-car propulsion were first adopted by a San Francisco inventor, and for many years have answered well, being the only system, until the employment of electricity, by which the heavy grades common to San Francisco streets could be overcome. While regarded by engineers as out of date, the only substitute possible to adopt was the underground electric trolley, which the companies objected to as too expensive. Only a first-class convulsion was effective in proving the weakness of the cable system and its surprising collapse with the first shock of earthquake and utter destruction when attacked by fire. With reference to the damage by earthquake and fire the chief engineer reports that the cable conduits throughout the city suffered great damage. The distortion of the street surfaces, both in vertical and horizontal planes, was sufficient to disable for a long period, if not destroy, a large percentage of any construction requiring accurate adjustment for cable operation. Where the disturbance was greatest the conduit suffered most. In places the roadbed sunk as much as 5 feet and was broken apart. The entire street was moved to the east four feet, making reverse curves in the cable slots at either end of the block. The cable slot was twisted and distorted beyond repair and it would be impossible to replace in successful operation any cable road damaged as this had been without reconstruction. On some lines the slot was closed by the shock and subsequently warped by fire. On many streets the track settled out of line in places from 6 to 18 inches. In places the line is moved to the west as much as 5 feet for a distance of 200 feet, sinking 3 feet. In the vicinity of Washington Street power house an examination before the fire showed that the slots suffered greatly before the fire and would have required entire reconstruction before operation. The drainage of the conduits was seriously affected by the shock. The power houses in every case were seriously damaged by the earthquake in which, aside from the fire, great damage was inflicted upon the machinery. The conclusions of the engineer are that in view of the necessity of a prompt supply of transportation to the city, "and to meet the present needs and the length of time necessary for repairing the cable system and the possibility of future earth disturbances, underground construction should not be renewed; and furthermore the city's transportation should not again be made dependent upon conduit construction."

SCIENCE NOTES.

The chemical investigation of raw materials often raises, unexpectedly, problems of great scientific interest. Examination of the seeds of the Para rubber tree (*Hevea brasiliensis*) has shown that they contain what proves to be a valuable drying oil, and in the course of the investigation it was ascertained that there is also present in the seeds an enzyme closely allied to, if not identical with, lipase, which is capable of splitting the oil by hydrolysis into glycerine and the free fatty acid. Subsequently, during the examination of other oil seeds similar enzymes have been detected, and it would appear probable that most oil seeds may prove to contain an enzyme capable of decomposing the fatty constituent.

A chemist working in the spirit of an investigator will be able to render special services to the cause of tropical agriculture, and it is therefore of importance that in future the men appointed to these posts should be chosen as far as possible on account of the promise they have shown as investigators. The determination of the constituents of little known indigenous plants as the first step toward ascertaining their economic value is another department of work which cannot be carried out without a chemist, and the same applies to the examination of poisonous plants, and also of minerals, in addition to the determination of the composition of foods and feeding stuffs. Tropical agriculture is a subject which is now of the first importance, especially in those countries in which the policy is to depend on a native population for the actual cultivation of the soil. Two functions must be performed: the one is to ascertain the nature and capabilities of the soil by actual experiments, for which well-organized experimental stations are a necessary part of every agricultural department; the other duty is to convey to the natives, chiefly by means of demonstration, the results of this experimental work, so that they may be persuaded to make it a part of their agricultural practice.

According to L'Aviculteur, the wholesale destruction, for purposes of millinery, of certain species of birds threatens at no distant date to bring about the extermination of some of the rarer and more beautiful kinds which the world possesses. How real this danger is may be estimated by the fact that in one market alone were sold lately at one time 12,000 humming birds, 28,000 parrakeets, 15,000 kingfishers, 20,000 aigrettes, and thousands of other gorgeous southern birds of different kinds, as well as doves and even sparrows. France receives every year from America, Tonkin, and India millions of birds, which are exchanged for millions of pounds. The number of small birds annually imported into England and France may be computed at 1,500,000. Germany exports yearly twenty million feathers, which are worked up in England into hat trimmings. In London there are held every month sales of birds' skins and feathers, India alone supplying some thirty millions of feathers. The South American republics have awakened to the danger of the extermination of their most ornamental species of birds, and have passed laws regulating their slaughter. A league has been formed in America, the members of which forswear the wearing of feathers; as the demand creates the supply, it is to be hoped more leagues of this kind will be formed elsewhere, and that it will be some day considered bad form for a woman to adorn her headgear or clothing with the bodies and feathers of wild birds.

It was recently noticed in a cold storage that candles or lamps began to burn with a feeble flame as soon as they were brought into the room, and that in many parts of it they were extinguished. A match could be lit, but the wax would not ignite. In the corner of the storeroom was a disused well, from which gas issued, and Mr. Bertram Blount, who was asked to investigate the cause of the trouble, at first supposed that carbon dioxide was being distributed into the air from this well. But this was not borne out by analysis of the air in the room and from the well, for the amount of carbon dioxide was only slightly more than is present in normal air, and was quite insufficient to have affected the combustion of a candle. Samples of air taken from different parts of the room contained only 17.5 to 17.7 per cent of oxygen, or from 3.2 to 3.4 per cent less than is present in normal air. The oxygen in the air in the shaft of the well amounted to no more than 8.6 to 8.9 per cent, and other experiments confirmed the conclusion that the air in the storeroom was ordinary air containing less than its proper proportion of oxygen, owing to admixture with air deprived of its oxygen, which issued from the well shaft. The source of the impoverished air from the well was finally traced to tunneling operations close by, in which compressed air was being used. This air must have found its way through the soil wherever it was sufficiently porous, and so into the shaft of the well, and on its passage through the soil must have been deprived of part of its oxygen by contact with some substance such as pyrites. Evidence in support of the correctness of this conclusion was furnished by the analysis of the mud from another well shaft near the first. This mud was found to contain pyrites, and air left in contact with it for some weeks was deprived of almost the whole of its oxygen.—Knowledge and Scientific News.

TRADE NOTES AND FORMULÆ.

Casein Cement.—In 95 parts of water dissolve 5 parts of borax and in the prepared liquid incorporate as much casein as will produce good consistency.—Nouvelles Scientifiques.

Piano Varnish.—The following will produce a very fine, uniformly smooth surface: 1½ parts of the white of egg, 8 parts of raw linseed oil, 2½ parts of alcohol, ½ part of orchal, 2 parts of chlorhydric acid, and 8 parts of vinegar.—Les Corps Gras Industriels.

To Color Copper Blue.—This receipt can be applied to brass. The object should be immersed in a liquid formed of 2 parts of liver of sulphur and 2 parts of chlorate of soda in 1,000 parts of water. A solution of 1 part of liver of sulphur in 50 parts of water may answer, if the object to be blued is kept in it for a certain time, while agitating continually.—Chimica Industriale.

Cement for Attaching Fabrics to Metals.—The following formula may be used in many cases. It consists of a mixture of 20 parts of starch, 10 parts of sugar, 1 part of zinc chloride, in 100 parts of water. All the ingredients should be mingled and stirred quite carefully so as to produce a homogeneous liquid. It should be warmed gently until it thickens.—Journal de l'Electrolyse.

Plaster Imitations of Ivory.—To communicate the patina and appearance of ivory to plaster objects, a coating may be applied made of white wax cut into small pieces and melted on the water bath in pure spirits of wine. The solution should have the consistency of a clear syrup. It may be colored a little in order to secure the tints of old ivory by adding yellow wax.—Chemische Revue.

Electric Tempering of Steel.—A reservoir of cast iron filled with a solution of carbonate of potash is connected with the positive pole of an electrical source. The steel tool to be tempered is fixed at the negative pole of the same machine. The electric current is made to pass while gradually immersing the tool in the solution of carbonate of potash until the part to be tempered is completely covered. The current is then cut off.—Journal de l'Electrolyse.

Orgeat Effervescent Powder.—This is designed for rendering beverages gaseous and piquant. It is composed of 450 parts of powdered sugars, 90 parts of carbonate of magnesia, and about 30 parts of citric acid, worked up carefully together. A few drops of oil of bitter almonds are incorporated gradually, and oil of vanilla to produce a slight perfume. The whole is mingled well, passed through a sieve, and put in a well-stoppered bottle until needed for employment.—Nouvelles Scientifiques.

To Clean Tapestry Papers.—Prepare a firm paste with 1 part of powdered pumice stone, 6 parts of wheat flour, and a sufficient quantity of water; make of this paste cylinders from 2 to 2½ inches in diameter and 7 or 8 inches long. Inclose these in muslin sewed as tight as possible and then put the rollers in a vessel containing boiling water, and continue the boiling for three-quarters of an hour. Take them out and leave at rest for twelve hours in a cool spot. Then take off the covering. They may be employed for rubbing the papers to be cleaned.—Moniteur de la Papeterie.

Polishing Paste for Metals.—A paste which is successful for metals where scratching is feared is made by dissolving 16 parts of soap, cut in small pieces, in the smallest quantity of water possible, on the water bath. Before cooling a hot solution is added of 2 parts of precipitated lime, 1 part of jewelers' red (calcined oxide of iron), 1 part of cream of tartar, and the same quantity of carbonate of magnesia. The whole is mixed until perfectly homogeneous, and a little water is added, if necessary for the formation of the paste. This is run into a rather shallow box, in order to be afterward cut up into tubes.—Zeitschrift für Analytische Chemie.

Formulas for Cold Cream.—First Formula: Mix together 425 parts of almond oil, 185 parts of lanoline, 62 parts of white wax and as much spermaceti; work up until a homogeneous mass is secured. Make another solution of 4½ parts of borax in 300 parts of rose water, and incorporate the solution in the creamy mass.

Second Formula: Mingle 125 parts of gum tragacanth and 100 parts of boracic acid in 140 parts of glycerine, add 50 parts of almond oil, as much glycerine, and ½ part of lavender oil; mixing these substances together before incorporating them. It remains to add the necessary quantities of water until a total weight of 1,000 parts is made up, forming a clear jelly of good consistency.—Journal de la Parfumerie et Savonnerie.

Birch Bud Water.—This is given by the Pharmaceutische Zeitung as a preparation having excellent cosmetic properties and valuable in the washing of the head. There are used for its preparation 3,500 parts of alcohol, 700 parts of water, 200 parts of potash soap, 150 parts of glycerine, 50 parts of the oil of birch buds, and 100 parts of various essential oils of fresh flowers; finally, a little chlorophyl, which acts simply as a colorant. The operation is begun by mixing the water with 700 parts of alcohol and dissolving the soap in this mixture. The oil is added, and the essential oil with the rest of the alcohol; then the soap mixture is poured in slowly, while constantly stirring. The glycerine is added last, and the whole is mixed carefully and allowed to stand for eight days; it is then filtered and colored with the chlorophyl. When employed, the liquid ought to be cut with an equal volume of water.

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